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ON BODIES SMALLER THAN ATOMS.

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THE masses of the atoms of the various gases were first investigated about thirty years ago by methods due to Loschmidt, Johnstone Stoney and Lord Kelvin. These physicists, using the principles of the kinetic theory of gases and making certain assumptions, which it must be admitted are not entirely satisfactory, as to the shape of the atom, determined the mass of an atom of a gas; and when once the mass of an atom of one substance is known the masses of the atoms of all other substances are easily deduced by well-known chemical considerations. The results of these investigations might be thought not to leave much room for the existence of anything smaller than ordinary atoms, for they showed that in a cubic centimeter of gas at atmospheric pressure and at 0° C. there are about 20 million, million, million (2×10^{19}) molecules of gas.

Though some of the arguments used to get this result are open to question, the result itself has been confirmed by considerations of quite a different kind. Thus Lord Rayleigh has shown that this number of molecules per cubic centimeter gives about the right value for the optical opacity of the air, while a method, which I will now describe, by which we can directly measure the number of molecules in a gas leads to a result almost identical with that of Loschmidt. This method is founded on Faraday's laws of electrolysis; we deduce from these laws that the current through an electrolyte is carried by the atoms of the electrolyte, and that all these atoms carry the same charge, so that the weight of the atoms required to carry a given quantity of electricity is proportional to the quantity carried. We know

too, by the results of experiments on electrolysis, that to carry the unit charge of electricity requires a collection of atoms of hydrogen which together weigh about $^1/_{10}$ of a milligram; hence if we can measure the charge of electricity on an atom of hydrogen we see that $^1/_{10}$ of this charge will be the weight in milligrams of the atom of hydrogen. This result is for the case when electricity passes through a liquid electrolyte. I will now explain how we can measure the mass of the carriers of electricity required to convey a given charge of electricity through a rarefied gas. In this case the direct methods which are applicable to liquid electrolytes cannot be used, but there are other, if more indirect, methods, by which we can solve the problem. The first case of conduction of electricity through gases we shall consider is that of the so-called cathode rays, those streamers from the negative electrode in a vacuum tube which produce the well-known green phosphorescence on the glass of the tube. These rays are now known to consist of negatively electrified particles moving with great rapidity. Let us see how we can determine the electric charge carried by a given mass of these particles. We can do this by measuring the effect of electric and magnetic forces on the particles. If these are charged with electricity they ought to be deflected when they are acted on by an electric force. It was some time, however, before such a deflection was observed, and many attempts to obtain this deflection were unsuccessful. The want of success was due to the fact that the rapidly moving electrified particles which constitute the cathode rays make the gas through which they pass a conductor of electricity; the particles are thus as it were moving inside conducting tubes which screen them off from an external electric field; by reducing the pressure of the gas inside the tube to such an extent that there was very little gas left to conduct, I was able to get rid of this screening effect and obtain the deflection of the rays by an electrostatic field. The cathode rays are also deflected by a magnet, the force exerted on them by the magnetic field is at right angles to the magnetic force, at right angles also to the velocity of the particle and equal to $Hev \sin \theta$ where H is the magnetic force, e the charge on the particle and θ the angle between H and v. Sir George Stokes showed long ago that, if the magnetic force was at right angles to the velocity of the particle, the latter would describe a circle whose radius is mv/eH (if m is the mass of the particle); we can measure the radius of this circle and thus find m/ve. To find v let an electric force F and a magnetic force H act simultaneously on the particle, the electric and magnetic forces being both at right angles to the path of the particle and also at right angles to each other. Let us adjust these forces so that the effect of the electric force which is equal to Fe just balances that of the magnetic force which is equal to Hev; when this is the case $Fe = Hev$ or $v = F/H$. We can thus find v, and knowing

from the previous experiment the value of vm/e, we deduce the value of m/e. The value of m/e found in this way was about 10^{-7}, and other methods used by Wiechert, Kaufmann and Lenard have given results not greatly different. Since $m/e = 10^{-7}$, we see that to carry unit charge of electricity by the particles forming the cathode rays only requires a mass of these particles amounting to one ten thousandth of a milligram while to carry the same charge by hydrogen atoms would require a mass of one-tenth of a milligram.*

Thus to carry a given charge of electricity by hydrogen atoms requires a mass a thousand times greater than to carry it by the negatively electrified particles which constitute the cathode rays, and it is very significant that, while the mass of atoms required to carry a given charge through a liquid electrolyte depends upon the kind of atom, being, for example, eight times greater for oxygen than for hydrogen atoms, the mass of cathode ray particles required to carry a given charge is quite independent of the gas through which the rays travel and of the nature of the electrode from which they start.

The exceedingly small mass of these particles for a given charge compared with that of the hydrogen atoms might be due either to the mass of each of these particles being very small compared with that of a hydrogen atom or *else to the charge carried by each particle being large compared with that carried by the atom of hydrogen.* It is therefore essential that we should determine the electric charge carried by one of these particles. The problem is as follows: suppose in an enclosed space we have a number of electrified particles each carrying the same charge, it is required to find the charge on each particle. It is easy by electrical methods to determine the total quantity of electricity on the collection of particles and knowing this we can find the charge on each particle if we can count the number of particles. To count these particles the first step is to make them visible. We can do this by availing ourselves of a discovery made by C. T. R. Wilson working in the Cavendish Laboratory. Wilson has shown that when positively and negatively electrified particles are present in moist dust-free air a cloud is produced when the air is closed by a sudden expansion, though this amount of expansion would be quite insufficient to produce condensation when no electrified particles are present: the water condenses round the electrified particles, and, if these are not too numerous, each particle becomes the nucleus of a little drop of water. Now

* Professor Schuster in 1889 was the first to apply the method of the magnetic deflection of the discharge to get a determination of the value of m/e; he found rather widely separated limiting values for this quantity and came to the conclusion that it was of the same order as in electrolytic solutions, the result of the method mentioned above as well as those of Wiechert, Kaufmann and Leonard make it very much smaller.

Sir George Stokes has shown how we can calculate the rate at which a drop of water falls through air if we know the size of the drop, and conversely we can determine the size of the drop by measuring the rate at which it falls through the air, hence by measuring the speed with which the cloud falls we can determine the volume of each little drop; the whole volume of water deposited by cooling the air can easily be calculated, and dividing the whole volume of water by the volume of one of the drops we get the number of drops, and hence the number of the electrified particles. We saw, however, that if we knew the number of particles we could get the electric charge on each particle; proceeding in this way I found that the charge carried by each particle was about 6.5×10^{-10} electrostatic units of electricity or 2.17×10^{-20} electro-magnetic units. According to the kinetic theory of gases, there are 2×10^{19} molecules in a cubic centimeter of gas at atmospheric pressure and at the temperature 0° C.; as a cubic centimeter of hydrogen weighs about 1/11 of a milligram each molecule of hydrogen weighs about $1/(22 \times 10^{19})$ milligrams and each atom therefore about $1/(44 \times 10^{19})$ milligrams and as we have seen that in the electrolysis of solutions one-tenth of a milligram carries unit charge, the atom of hydrogen will carry a charge equal to $10/(44 \times 10^{19}) = 2.27 \times 10^{-20}$ electro-magnetic units. The charge on the particles in a gas we have seen is equal to 2.17×10^{-20} units, these numbers are so nearly equal that, considering the difficulties of the experiments, we may feel sure that the charge on one of these gaseous particles is the same as that on an atom of hydrogen in electrolysis. This result has been verified in a different way by Professor Townsend, who used a method by which he found, not the absolute value of the electric charge on a particle, but the ratio of this charge to the charge on an atom of hydrogen and he found that the two charges were equal.

As the charges on the particle and the hydrogen atom are the same, the fact that the mass of these particles required to carry a given charge of electricity is only one-thousandth part of the mass of the hydrogen atoms shows that the mass of each of these particles is only about 1/1000 of that of a hydrogen atom. These particles occurred in the cathode rays inside a discharge tube, so that we have obtained from the matter inside such a tube particles having a much smaller mass than that of the atom of hydrogen, the smallest mass hitherto recognized. These negatively electrified particles, which I have called corpuscles, have the same electric charge and the same mass whatever be the nature of the gas inside the tube or whatever the nature of the electrodes; the charge and mass are invariable. They therefore form an invariable constituent of the atoms or molecules of all gases and presumably of all liquids and solids.

Nor are the corpuscles confined to the somewhat inaccessible

regions in which cathodic rays are found. I have found that they are given off by incandescent metals, by metals when illuminated by ultra-violet light, while the researches of Becquerel and Professor and Madame Curie have shown that they are given off by that wonderful substance the radio-active radium.

In fact in every case in which the transport of negative electricity through gas at a low pressure (*i. e.*, when the corpuscles have nothing to stick to) has been examined, it has been found that the carriers of the negative electricity are these corpuscles of invariable mass.

A very different state of things holds for the positive electricity. The masses of the carriers of positive electricity have been determined for the positive electrification in vacuum tubes by Wien and by Ewers, while I have measured the same thing for the positive electrification produced in a gas by an incandescent wire. The results of these experiments show a remarkable difference between the property of positive and negative electrification, for the positive electricity, instead of being associated with a constant mass 1/1000 of that of the hydrogen atom, is found to be always connected with a mass which is of the same order as that of an ordinary molecule and which, moreover, varies with the nature of the gas in which the electrification is found.

These two results, the invariability and smallness of the mass of the carriers of negative electricity, and the variability and comparatively large mass of the carriers of positive electricity, seem to me to point unmistakably to a very definite conception as to the nature of electricity. Do they not obviously suggest that negative electricity consists of these corpuscles or, to put it the other way, that these corpuscles are negative electricity, and that positive electrification consists in the absence of these corpuscles from ordinary atoms? Thus this point of view approximates very closely to the old one-fluid theory of Franklin; on that theory electricity was regarded as a fluid, and changes in the state of electrification were regarded as due to the transport of this fluid from one place to another. If we regard Franklin's electric fluid as a collection of negatively electrified corpuscles, the old one-fluid theory will, in many respects, express the results of the new. We have seen that we know a good deal about the 'electric fluid'; we know that it is molecular or rather corpuscular in character; we know the mass of each of these corpuscles and the charge of electricity carried by it; we have seen too that the velocity with which the corpuscles move can be determined without difficulty. In fact the electric fluid is much more amenable to experiment than an ordinary gas, and the details of its structure are more easily determined.

Negative electricity (*i. e.*, the electric fluid) has mass; a body negatively electrified has a greater mass than the same body in the

neutral state; positive electrification, on the other hand, since it involves the absence of corpuscles, is accompanied by a diminution in mass.

An interesting question arises as to the nature of the mass of these corpuscles which we may illustrate in the following way. When a charged corpuscle is moving, it produces in the region around it a magnetic field whose strength is proportional to the velocity of the corpuscle; now in a magnetic field there is an amount of energy proportional to the square of the strength, and thus, in this case, proportional to the square of the velocity of the corpuscle.

Thus if e is the electric charge on the corpuscle and v its velocity, there will be in the region round the corpuscle an amount of energy equal to $\frac{1}{2}\beta e^2v^2$ where β is a constant which depends upon the shape and size of the corpuscle. Again if m is the mass of the corpuscle its kinetic energy is $\frac{1}{2}mv^2$, and thus the total energy due to the moving electrified corpuscle is $\frac{1}{2}(m+\beta e^2)v^2$, so that for the same velocity it has the same kinetic energy as a non-electrified body whose mass is greater than that of the electrified body by βe^2. Thus a charged body possesses in virtue of its charge, as I showed twenty years ago, an apparent mass apart from that arising from the ordinary matter in the body. Thus in the case of these corpuscles, part of their mass is undoubtedly due to their electrification, and the question arises whether or not the whole of their mass can be accounted for in this way. I have recently made some experiments which were intended to test this point; the principle underlying these experiments was as follows: if the mass of the corpuscle is the ordinary 'mechanical' mass, then, if a rapidly moving corpuscle is brought to rest by colliding with a solid obstacle, its kinetic energy being resident in the corpuscle will be spent in heating up the molecules of the obstacle in the neighborhood of the place of collision, and we should expect the mechanical equivalent of the heat produced in the obstacle to be equal to the kinetic energy of the corpuscle. If, on the other hand, the mass of the corpuscle is 'electrical,' then the kinetic energy is not in the corpuscle itself, but in the medium around it, and, when the corpuscle is stopped, the energy travels outwards into space as a pulse confined to a thin shell traveling with the velocity of light. I suggested some time ago that this pulse forms the Röntgen rays which are produced when the corpuscles strike against an obstacle. On this view, the first effect of the collision is to produce Röntgen rays and thus, unless the obstacle against which the corpuscle strikes absorbs all these rays, the energy of the heat developed in the obstacle will be less than the energy of the corpuscle. Thus, on the view that the mass of the corpuscle is wholly or mainly electrical in its origin, we should expect the heating effect to be smaller when the corpuscles strike against a target per-

meable by the Röntgen rays given out by the tube in which the corpuscles are produced than when they strike against a target opaque to these rays. I have tested the heating effects produced in permeable and opaque targets, but have never been able to get evidence of any considerable difference between the two cases. The differences actually observed were small compared with the total effect and were sometimes in one direction and sometimes in the opposite. The experiments, therefore, tell against the view that the whole of the mass of a corpuscle is due to its electrical charge. The idea that mass in general is electrical in its origin is a fascinating one, although it has not at present been reconciled with the results of experience.

The smallness of these particles marks them out as likely to afford a very valuable means for investigating the details of molecular structure, a structure so fine that even waves of light are on far too large a scale to be suitable for its investigation, as a single wave length extends over a large number of molecules. This anticipation has been fully realized by Lenard's experiments on the obstruction offered to the passage of these corpuscles through different substances. Lenard found that this obstruction depended only upon the density of the substance and not upon its chemical composition or physical state. He found that, if he took plates of different substances of equal areas and of such thicknesses that the masses of all the plates were the same, then, no matter what the plates were made of, whether of insulators or conductors, whether of gases, liquids or solids, the resistance they offered to the passage of the corpuscles through them was the same. Now this is exactly what would happen if the atom of the chemical elements were aggregations of a large number of equal particles of equal mass; the mass of an atom being proportional to the number of these particles contained in it and the atom being a collection of such particles through the interstices between which the corpuscle might find its way. Thus a collision between a corpuscle and an atom would not be so much a collision between the corpuscle and the atom as a whole, as between a corpuscle and the individual particles of which the atom consists; and the number of collisions the corpuscle would make, and therefore the resistance it would experience, would be the same if the number of particles in unit volume were the same, whatever the nature of the atoms might be into which these particles are aggregated. The number of particles in unit volume is however fixed by the density of the substance and thus on this view the density and the density alone should fix the resistance offered by the substance to the motion of a corpuscle through it; this, however, is precisely Lenard's result, which is thus a strong confirmation of the view that the atoms of the elementary substances are made up of simpler parts all of which are alike. This and similar views of the constitu-

tion of matter have often been advocated; thus in one form of it, known as Prout's hypothesis, all the elements were supposed to be compounds of hydrogen. We know, however, that the mass of the primordial atom must be much less than that of hydrogen. Sir Norman Lockyer has advocated the composite view of the nature of the elements on spectroscopic grounds, but the view has never been more boldly stated than it was long ago by Newton who says:

"The smallest particles of matter may cohere by the strongest attraction and compose bigger particles of weaker virtue and many of these may cohere and compose bigger particles whose virtue is still weaker and so on for divers succession, until the progression ends in the biggest particles on which the operations in Chemistry and the colours of natural bodies depend and which by adhering compose bodies of a sensible magnitude."

The reasoning we used to prove that the resistance to the motion of the corpuscle depends only upon the density is only valid when the sphere of action of one of the particles on a corpuscle does not extend as far as the nearest particle. We shall show later on that the sphere of action of a particle on a corpuscle depends upon the velocity of the corpuscle, the smaller the velocity the greater being the sphere of action and that if the velocity of the corpuscle falls as low as 10^7 centimeters per second, then, from what we know of the charge on the corpuscle and the size of molecules, the sphere of action of the particle might be expected to extend further than the distance between two particles and thus for corpuscles moving with this and smaller velocities we should not expect the density law to hold.

Existence of Free Corpuscles or Negative Electricity in Metals.

In the cases hitherto described the negatively electrified corpuscles had been obtained by processes which require the bodies from which the corpuscles are liberated to be subjected to somewhat exceptional treatment. Thus in the case of the cathode rays the corpuscles were obtained by means of intense electric fields, in the case of the incandescent wire by great heat, in the case of the cold metal surface by exposing this surface to light. The question arises whether there is not to some extent, even in matter in the ordinary state and free from the action of such agencies, a spontaneous liberation of those corpuscles—a kind of dissociation of the neutral molecules of the substance into positively and negatively electrified parts, of which the latter are the negatively electrified corpuscles.

Let us consider the consequences of some such effect occurring in a metal, the atoms of the metal splitting up into negatively electrified corpuscles and positively electrified atoms and these again after a time re-combining to form neutral system. When things have got into a steady state the number of corpuscles re-combining in a given time will be equal to the number liberated in the same time. There will

thus be diffused through the metal swarms of these corpuscles, these will be moving about in all directions like the molecules of a gas and, as they can gain or lose energy by colliding with the molecule of the metal, we should expect by the kinetic theory of gases that they will acquire such an average velocity that the mean kinetic energy of a corpuscle moving about in the metal is equal to that possessed by a molecule of a gas at the temperature of the metal; this would make the average velocity of the corpuscles at 0° C. about 10^7 centimeters per second. This swarm of negatively electrified corpuscles when exposed to an electric force will be sent drifting along in the direction opposite to the force; this drifting of the corpuscles will be an electric current, so that we could in this way explain the electrical conductivity of metals.

The amount of electricity carried across unit area under a given electric force will depend upon and increase with (1) the number of free corpuscles per unit volume of the metal, (2) the freedom with which these can move under the force between the atoms of the metal; the latter will depend upon the average velocity of these corpuscles, for if they are moving with very great rapidity the electric force will have very little time to act before the corpuscle collides with an atom, and the effect produced by the electric force annulled. Thus the average velocity of drift imparted to the corpuscles by the electric field will diminish as the average velocity of translation, which is fixed by the temperature, increases. As the average velocity of translation increases with the temperature, the corpuscles will move more freely under the action of an electric force at low temperatures than at high, and thus from this cause the electrical conductivity of metals would increase as the temperature diminishes. In a paper presented to the International Congress of Physics at Paris in the autumn of last year, I described a method by which the number of corpuscles per unit volume and the velocity with which they moved under an electric force can be determined. Applying this method to the case of bismuth, it appears that at the temperature of 20° C. there are about as many corpuscles in a cubic centimeter as there are molecules in the same volume of a gas at the same temperature and at a pressure of about ¼ of an atmosphere, and that the corpuscles under an electric field of 1 volt per centimeter would travel at the rate of about 70 meters per second. Bismuth is at present the only metal for which the data necessary for the application of this method exists, but experiments are in progress at the Cavendish Laboratory which it is hoped will furnish the means for applying the method to other metals. We know enough, however, to be sure that the corpuscles in good conductors, such as gold, silver or copper, must be much more numerous than in bismuth, and that the corpuscular pres-

sure in these metals must amount to many atmospheres. These corpuscles increase the specific heat of a metal and the specific heat gives a superior limit to the number of them in the metal.

An interesting application of this theory is to the conduction of electricity through thin films of metal. Longden has recently shown that when the thickness of the film falls below a certain value, the specific resistance of the film increases rapidly as the thickness of the film diminishes. This result is readily explained by this theory of metallic conduction, for when the film gets so thin that its thickness is comparable with the mean free path of a corpuscle the number of collisions made by a corpuscle in a film will be greater than in the metal in bulk, thus the mobility of the particles in the film will be less and the electrical resistance consequently greater.

The corpuscles disseminated through the metal will do more than carry the electric current, they will also carry heat from one part to another of an unequally heated piece of metal. For if the corpuscles in one part of the metal have more kinetic energy than those in another, then, in consequence of the collisions of the corpuscles with each other and with the atoms, the kinetic energy will tend to pass from those places where it is greater to those where it is less, and in this way heat will flow from the hot to the cold parts of the metal, as the rate with which the heat is carried will increase with the number of corpuscles and with their mobility, it will be influenced by the same circumstances as the conduction of electricity, so that good conductors of electricity should also be good conductors of heat. If we calculate the ratio of the thermal to the electric conductivity on the assumption that the whole of the heat is carried by the corpuscles we obtain a value which is of the same order as that found by experiment.

Weber many years ago suggested that the electrical conductivity of metals was due to the motion through them of positively and negatively electrified particles, and this view has recently been greatly extended and developed by Riecke and by Drude, the objection to any electrolytic view of the conduction through metals is that, as in electrolysis, the transport of electricity involves the transport of matter, and no evidence of this has been detected, this objection does not apply to the theory sketched above, as on this view it is the corpuscles which carry the current, these are not atoms of the metal, but very much smaller bodies which are the same for all metals.

It may be asked if the corpuscles are disseminated through the metal and moving about in it with an average velocity of about 10^7 centimeters per second, how is it that some of them do not escape from the metal into the surrounding air? We must remember, however, that these negatively electrified corpuscles are attracted by the positively electrified atoms and in all probability by the neutral atoms as well, so

that to escape from these attractions and get free a corpuscle would have to possess a definite amount of energy, if a corpuscle had less energy than this then, even though projected away from the metal, it would fall back into it after traveling a short distance. When the metal is at a high temperature, as in the case of the incandescent wire, or when it is illuminated by ultra-violet light some of the corpuscles acquire sufficient energy to escape from the metal and produce electrification in the surrounding gas. We might expect too that, if we could charge a metal so highly with negative electricity, that the work done by the electric field on the corpuscle in a distance not greater than the sphere of action of the atoms on the corpuscles was greater than the energy required for a corpuscle to escape, then, the corpuscles would escape and negative electricity stream from the metal. In this case the discharge could be effected without the participation of the gas surrounding the metal and might even take place in an absolute vacuum, if we could produce such a thing. We have as yet no evidence of this kind of discharge, unless indeed some of the interesting results recently obtained by Earhart with very short sparks should be indications of an effect of this kind.

A very interesting case of the spontaneous emission of corpuscles is that of the radio-active substance radium discovered by M. and Madame Curie. Radium gives out negatively electrified corpuscles which are deflected by a magnet. Becquerel has determined the ratio of the mass to the charge of the radium corpuscles and finds it is the same as for the corpuscles in the cathode rays. The velocity of the radium corpuscles is, however, greater than any that has hitherto been observed for either cathode or Lenard rays: being, as Becquerel found, as much as 2×10^{10} centimeters per second or two-thirds the velocity of light. This enormous velocity explains why the corpuscles from radium are so very much more penetrating than the corpuscles from cathode or Lenard rays; the difference in this respect is very striking, for while the latter can only penetrate solids when they are beaten out into the thinnest films, the corpuscles from radium have been found by Curie to be able to penetrate a piece of glass 3 millimeters thick. To see how an increase in the velocity can increase the penetrating power, let us take as an illustration of a collision between the corpuscle and the particles of the metal the case of a charged corpuscle moving past an electrified body; a collision may be said to occur between these when the corpuscle comes so close to the charged body that its direction of motion after passing the body differs appreciably from that with which it started. A simple calculation shows that the deflection of the corpuscle will only be considerable when the kinetic energy, with which the corpuscle starts on its journey towards the charged body is not large compared with the work done

by the electric forces on the corpuscle in its journey to the shortest distance from the charged body. If d is the shortest distance, e and e' the charge of the body and corpuscles, the work done is ee'/d; while if m is the mass and v the velocity with which the corpuscle starts the kinetic energy to begin with is $\frac{1}{2}mv^2$; thus a considerable deflection of the corpuscle, *i. e.*, a collision will occur only when ee'/d is comparable with $\frac{1}{2}mv^2$; and d, the distance at which a collision occurs, will vary inversely as v^2. As d is the radius of the sphere of action for collision and as the number of collisions is proportional to the area of a section of this sphere, the number of collisions is proportional to d^2, and therefore varies inversely as v^4. This illustration explains how rapidly the number of collisions and therefore the resistance offered to the motion of the corpuscles through matter diminishes as the velocity of the corpuscles increases, so that we can understand why the rapidly moving corpuscles from radium are able to penetrate substances which are nearly impermeable to the more slowly moving corpuscles from cathode and Lenard rays.

Cosmical Effects Produced by Corpuscles.

As a very hot metal emits these corpuscles it does not seem an improbable hypothesis that they are emitted by that very hot body, the sun. Some of the consequences of this hypothesis have been developed by Paulsen, Birkeland and Arrhenius who have developed a theory of the Aurora Borealis from this point of view. Let us suppose that the sun gives out corpuscles which travel out through interplanetary space; some of these will strike the upper regions of the Earth's atmosphere and will then or even before then, come under the influnce of the Earth's magnetic field. The corpuscles when in such a field, will describe spirals round the lines of magnetic force; as the radii of these spirals will be small compared with the height of the atmosphere; we may for our present purpose suppose that they travel along the lines of the Earth's magnetic force. Thus the corpuscles which strike the earth's atmosphere near the equatorial regions where the lines of magnetic force are horizontal will travel horizontally, and will thus remain at the top of the atmosphere where the density is so small that but little luminosity is caused by the passage of the corpuscles through the gas; as the corpuscles travel into higher latitudes where the lines of magnetic force dip, they follow these lines and descend into the lower and denser parts of the atmosphere, where they produce luminosity, which on this view is the Aurora.

As Arrhenius has pointed out the intensity of the Aurora ought to be a maximum at some latitude intermediate between the pole and the equator, for, though in the equatorial regions the rain of corpuscles from the sun is greatest, the earth's magnetic force keeps these in

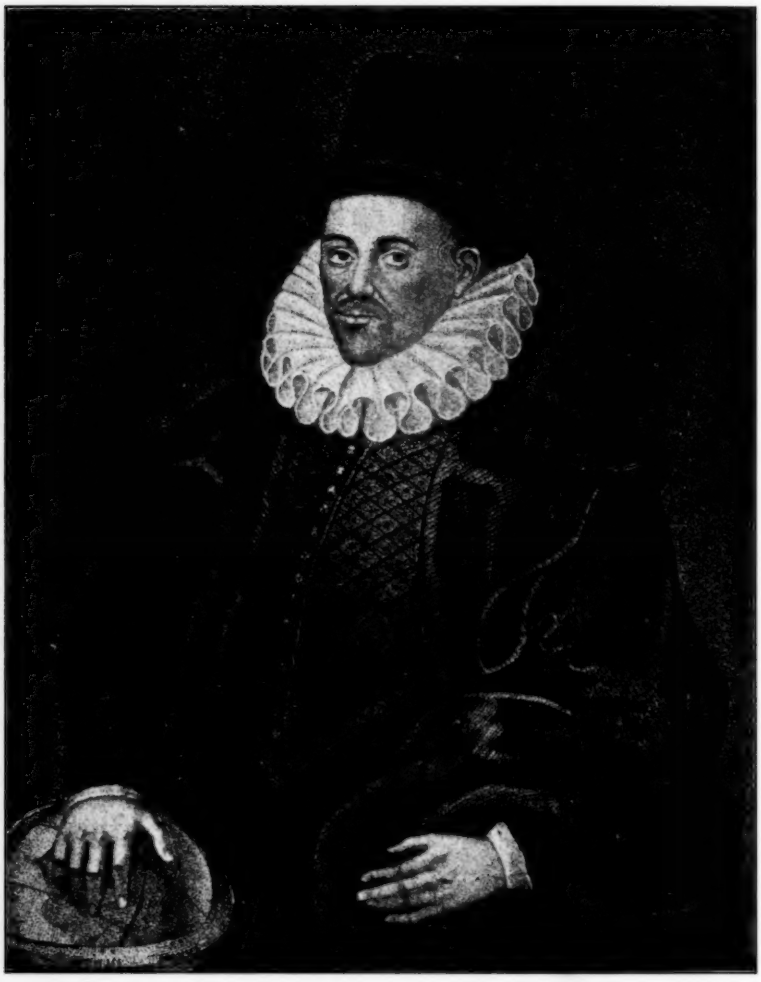
such highly rarefied gas that they produce but little luminosity, while at the pole, where the magnetic force would pull them straight down into the denser air, there are not nearly so many corpuscles; the maximum luminosity will therefore be somewhere between these places. Arrhenius has worked out this theory of the Aurora very completely and has shown that it affords a very satisfactory explanation of the various periodic variations to which it is subject.

As a gas becomes a conductor of electricity when corpuscles pass through it, the upper regions of the air will conduct, and when air currents occur in these regions, conducting matter will be driven across the lines of force due to the earth's magnetic field, electric currents will be induced in the air, and the magnetic force due to these currents will produce variations in the earth's magnetic field. Balfour Stewart suggested long ago that the variation on the earth's magnetic field was caused by currents in the upper regions of the atmosphere, and Schuster has shown, by the application of Gauss' method, that the seat of these variations is above the surface of the earth.

The negative charge in the earth's atmosphere will not increase indefinitely in consequence of the stream of negatively electrified corpuscles coming into it from the sun, for as soon as it gets negatively electrified it begins to repel negatively electrified corpuscles from the ionized gas in the upper regions of the air, and a state of equilibrium will be reached when the earth has such a negative charge that the corpuscles driven by it from the upper regions of the atmosphere are equal in number to those reaching the earth from the sun. Thus, on this view, interplanetary space is thronged with corpuscular traffic, rapidly moving corpuscles coming out from the sun while more slowly moving ones stream into it.

In the case of a planet which, like the moon, has no atmosphere there will be no gas for the corpuscles to ionize, and the negative electrification will increase until it is so intense that the repulsion exerted by it on the corpuscles is great enough to prevent them from reaching the surface of the planet.

Arrhenius has suggested that the luminosity of nebulæ may not be due to high temperature, but may be produced by the passage through their outer regions of the corpuscles wandering about in space, the gas in the nebulæ being quite cold. This view seems in some respects to have advantages over that which supposes the nebulæ to be at very high temperatures. These and other illustrations, which might be given did space permit, seem to render it probable that these corpuscles may play an important part in cosmical as well as in terrestrial physics.



DR. WILLIAM GILBERT.

THE PHILOSOPHER OF COLCHESTER.

GILBERT OF COLCHESTER.

THE TERCENTENARY OF ELECTRIC AND MAGNETIC SCIENCE.

By BROTHER POTAMIAN, D.Sc., Lond.,
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AT a period when natural science was taught and studied in the schools of Europe from text-books, we find Gilbert of Colchester proclaiming by example and advocacy the paramount value of experiment for the advancement of learning. He was unsparing in his denunciation of the superficiality and verbosity of mere bookmen, and had no patience with writers who treated their subjects 'esoterically, reconditely and mystically.' For him, the laboratory method was the only one that could secure fruitful results and effectively push back the frontiers of knowledge.

It is true that men of unusual ability and strong character strove before his time to adjust the claims of authority in matters scientific. While respectful of the teachings of recognized leaders, they were not awed into acquiescence by the customary academical 'magister dixit.' On the contrary, they wanted to test with their eyes in order to judge with reason; believing in the supreme importance of experiment, they sought to acquire a knowledge of nature from nature herself.

Such were Albert the Great and Friar Bacon. Albert did not bow obsequiously to the authority of Aristotle or any of his Arabian commentators; he investigated for himself and became, for his age, a distinguished botanist and physiologist.

Roger Bacon, after absorbing the learning of Oxford and Paris, wrote to the reigning Pontiff, Clement IV., urging him to have the works of the Stagyrite burnt in order to stop the propagation of error in the schools. The Franciscan monk of Ilchester has left us in his *Opus Majus* a lasting memorial of his practical genius. In the section entitled 'Scientia Experimentalis,' he affirms that "Without experiment, nothing can be adequately known. An argument proves theoretically but does not give the certitude necessary to remove all doubt, nor will the mind repose in the clear view of truth, unless it find it by way of experiment." And in his *Opus Tertium:* "The strongest arguments prove nothing so long as the conclusions are not verified by experience. Experimental science is the queen of sciences and the goal of all speculation."

No one, even in our own times, ever wrote more strongly in favor of the practical method than did this follower of St. Francis in the thirteenth century. Being convinced that there can be no conflict between scientific and revealed truths, he became an irrepressible advocate for observation and experiment in the study of the phenomena and forces of nature.

The example of Albert and of Friar Bacon, not to mention others like Vincent of Beauvais, the Dominican encyclopedist, was, however, not sufficient to wean students and professors from the easy-going routine of book-learning. A few centuries had to elapse before the weaning was effectively begun; and the man who powerfully contributed to this result was Dr. William Gilbert, the philosopher of Colchester.

Gilbert was born in Colchester * in 1540 in a house which, thanks to the appreciation of the authorities of that ancient town, the writer found in an excellent state of preservation on the occasion of his visit in quest of Gilbertiana.

Having received the elements of his education in the grammar school of his native town, Gilbert entered St. John's College, Cambridge. He graduated in 1560, 'commenced' M. A. in 1564, and took his M. D. degree in 1569. On leaving the university, he traveled for some time on the Continent, where he made the acquaintance of several distinguished scholars. On his return to England he practised, we are told, 'with great success and applause.' His reputation obtained for him the presidency of the Royal College of Physicians for the year 1600, and ultimately led to his being appointed physician in ordinary to the Queen (Elizabeth).

We are not here concerned with Gilbert as a physician and still less as a courtier. His claims to enduring recognition are of a higher order, for we regard him not only as the author of a monumental work of physical research, but also as founder, by word and deed, of the Experimental School of philosophy.

In his address to the 'candid reader' at the beginning of *De Magnete*† he pointedly says:

"To you alone, true philosophers, ingenuous minds, who not only in books, but in things themselves, look for knowledge, have I dedicated a new style of philosophizing. But if any of you see fit not to agree with the opinions expressed, let them note the great multitude of experiments and discoveries, for it is these that cause all philosophy to flourish: we have dug them up and demonstrated them with much pains and sleepless nights and great money expense."

Further on he adds:

"Nor did we find this, our labor, vain and fruitless, for every day in our experiments novel and unheard of properties came to light."

* A town in Essex, fifty miles northeast of London.

† The only English translation of this work which we have is by Mr. P. Henry Mottelay, of New York, published by Wiley & Sons.

On one occasion, he hears that Baptista Porta, whom he calls 'a philosopher of no ordinary note,' said that a piece of iron rubbed with a diamond turns to the north. He suspects this to be heresy. So, forthwith he proceeds to test the statement by experiment. He was not dazzled by the reputation of Baptista Porta; he respected Porta, but respected truth even more. He tells us that he experimented with seventy-five diamonds in presence of many witnesses, employing a number of iron bars and pieces of wire, manipulating them with the greatest care while they floated on corks; and he concludes his long and exhaustive research by plaintively saying: "Yet never was it granted me to see the effect mentioned by Porta."

Though it led to a negative result, this probing inquiry was a masterpiece of experimental work.

Gilbert incidentally regrets that the men of his time "are deplorably ignorant with respect to natural things," and the only way he sees to remedy this is to make them "quit the sort of learning that comes only from books and that rests only on vain arguments and conjectures," for he shrewdly remarks that "even men of acute intelligence without actual knowledge of facts and in the absence of experiment easily fall into error."

Acting on this intimate conviction, he labored for eighteen years over the theories and experiments which he sets forth in his great work on the magnet. "There is naught in these books," he tells us, "that has not been investigated, and again and again done and repeated under our eyes." He begs any one that should feel disposed to challenge his results to repeat the experiments for himself "carefully, skilfully and deftly, but not heedlessly and bunglingly."

It has often been said that we are indebted to Sir Francis Bacon, Queen Elizabeth's Chancellor, for the inductive method of studying the phenomena of nature. This is an error, for all investigators employed it from Archimedes the Syracusan down to Gilbert, the contemporary of Lord Verulam.* Bacon's merit lies in the fact that he not only minutely analyzed the method, pointing out its uses and abuses, but also that he admitted it to be the only one by which we can attain an accurate knowledge of the physical world around us. His sententious eulogy went forth to the world of scholars invested with all the importance, authority and dignity which the high position and world-wide fame of the philosophic Chancellor could give it. But while Bacon thought and wrote in his study, Gilbert labored and toiled in his workshop. By his quill, Bacon made a profound impression on the philosophic mind of his age; by his researches, Gilbert explored two

* Bacon was raised to the peerage as Baron Verulam, and was subsequently created Viscount St. Albans; where, then, is the propriety of calling him Lord Bacon?

vast provinces of nature and added them to the domain of science. Bacon was a theorist, Gilbert an investigator. For eighteen years and more he shunned the glare of society and the throbbing excitement of public life; he wrenched himself away from all but the strictest exigencies of his profession, in order to devote himself undistractedly to the pursuit of science. And all this more than twenty years before the appearance of Bacon's *Novum Organum*, the very work which contains the philosopher's 'large thoughts and lofty phrases' on the value of experiment as a means for the advancement of learning. During that long period Gilbert haunted Colchester, where he delved into the secrets of nature and prepared the materials for his grand work, *De Magnete*. The publication of this Latin treatise made him known in the universities at home and especially abroad: he was appreciated by all the great physicists and mathematicians of his age; by such men as Sir Kenelm Digby; by William Barlowe, a great 'magneticall' man; by Kepler, the astronomer, who adopted and defended his views; by Galileo himself, who said: 'I extremely admire and envy the author of *De Magnete*.'

If any one then deserves to be called the founder of the experimental school of philosophy, we contend that it is not Bacon the thinker and essayist, but Gilbert the methodical worker and fruitful discoverer.

The originality of Gilbert's work and the character of his discoveries, together with the reputation which he enjoyed in the greater seats of learning, ended by giving umbrage to Bacon, and the world saw the strange spectacle of a great chancellor forgetting the teachings of his own philosophy and becoming jealous. He even carried his ill feeling so far as to write belittlingly of the conclusions of his illustrious rival, saying in his *De Augmentis Scientiarum* that "Gilbert had attempted a general system upon the magnet, endeavoring to build a ship out of materials not sufficient to make the rowing-pins of a boat."

It will be interesting to see what these 'rowing-pins' were, for then we shall have a scale by which to judge the intensity of Bacon's jealousy and the magnitude of his belittling ability.

II.

Gilbert's electrical work is contained in Book II of *De Magnete;* and we may say at once that the second chapter of that famous book is the first chapter on electricity ever written. Nothing was known before Gilbert's time save the attraction for light bodies observed in rubbed amber and jet.

Gilbert goes to work and devises an instrument to enable him to study readily the electrical behavior of rubbed substances. He called it a Versorium, we should call it an electroscope. "Make to yourself," he says, "a rotating needle of any sort of metal three or four fingers long and pretty light and poised on a sharp point." He then briskly

rubs and brings near his versorium glass, sulphur, opal, diamond, sapphire, carbuncle, rock-crystal, sealing-wax, alum, resin, etc., and he finds that all these attract his suspended needle, and not only the needle, but everything else. His words are remarkable: 'Ad electrica feruntur omnia.'* Here is a great advance on the amber and jet, the only two bodies previously known as having the power to attract 'straws, chaff and twigs,' the usual test-substances of the ancients. Pursuing his investigations, he finds a class of bodies which perplex him, because when rubbed they do not affect his electroscope. Among these he enumerates: bone, ivory, marble, flint, silver, copper, gold, iron, even the lodestone itself. The former class he called *electrica,* electrics, deriving the term from *elektron,* the Greek name for amber; the latter class he termed *anelectrica,* non-electrics.

Science therefore owes to Gilbert the terms electric and electrical; the term electricity was a coinage of a later period, due probably to the illustrious Irish philosopher, Robert Boyle, who uses the term in his work *On the Mechanical Production of Electricity,* published in 1675.† Gilbert never uses *electricitas,* but speaks of corpora electrica, effluvia electrica, attractio electrica, motus electricus and the like. Had Gilbert chosen the Latin name for amber, *succinum,* as he might have done, we should not be speaking to-day of electricity, electrostatics, electro-optics, electrics, dielectrics; but should probably be using succinic for electric, succinical for electrical, succinicity for electricity, together with a series of harsh-sounding derivatives and compounds.

As we said, Gilbert was perplexed by the anomalous behavior of his anelectrics. He toiled and labored hard to find out the cause. He undertook a long, abstract, philosophical discussion of the nature of bodies which, from its very subtlety, failed to reveal the cause of his perplexing anomaly. Gilbert failed to discover the distinction between conductors and insulators, and, as a consequence, never found out that similarly electrified bodies repel each other. Had he but suspended an excited stick of sealing-wax, what a promised land of electrical wonders would have unfolded itself to his vision! and what a harvest of results such a reaper would have gathered in! He noticed the effect of distance; for he says, 'The nearer the electric is to the versorium, the quicker is the attraction.' It was reserved, however, for the French mathematician and engineer, Coulomb, to show in 1785 that the law of attraction or repulsion between two electrified particles varies inversely as the square of the distance between them.

From solids, he proceeds to examine the behavior of some liquids, and finds that they too are susceptible of electrical influence. He notices that a piece of excited amber when brought near a drop of water

* All things are drawn to electrics.

† To Boyle we are also indebted for the name barometer.

deforms it, drawing it out into a conical shape. He even experiments with smoke, concluding that the small carbon particles are attracted by an electrified body. It was only a few years ago that Dr. Oliver Lodge, extending this observation, proposed to lay the poisonous dust floating about in the atmosphere of lead works by means of large electrostatic machines. He even hinted in his Royal Institution lecture that they might be useful in dissipating mists and fogs, recommending that a trial be made on some of our ocean-bound steamers.

Gilbert next tries heat as an agent to produce electrification. He takes a red-hot coal and finds that it has no effect on his electroscope; he heats a mass of iron up to whiteness and finds that it too exerts no electrical effect. He tries a flame, a candle, a burning torch, and concludes that all bodies are attracted by electrics save those that are afire or flaming, or extremely rarefied. He then reverses the experiment and brings near an excited body the flame of a lamp, and he ingenuously states that the body no longer attracts the pivoted needle. He thus discovered the neutralizing effect of flames, and supplied us with the readiest means we have to-day of discharging non-conductors.

He goes a step further; for we find him exposing some of his electrics to the action of the sun's rays in order to see whether they acquired a charge; but all his results were negative. He then concentrates the rays of the sun by means of lenses, evidently expecting some electrical effect; but finding none, he concludes with a vein of pathos that the sun imparts no power, but dissipates and spoils the electric effluvium.

Professor Righi has shown that a clean metallic plate acquires a positive charge when exposed to the ultra-violet radiation from any artificial source of light, but that it does not when exposed to solar rays. The absence of electrical effects in the latter case is attributed to the absorptive action of the atmosphere on the shorter waves of the solar beam.

Of course, Gilbert permits himself some speculation as to the nature of the agent he was dealing with. He thought of it, reasoned about it, pursued it in every way; and came to the conclusion that it must be something extremely tenuous indeed, but yet substantial, ponderable, material. "As air is the effluvium of the earth," he says, "so electrified bodies have an effluvium of their own, which they emit when stimulated or excited;" and again: "It is probable that amber exhales something peculiar that attracts the bodies themselves."

In 1862, another Gilbert, Sir Wm. Thomson (now Lord Kelvin), writing to his friend, Professor Tait, of Edinburgh, said: "Tell me what electricity is and I'll tell you everything else"; and in April, 1893, the same Lord Kelvin, replying to the writer, added: "I see no reason to say otherwise than what you tell me I said to Professor Tait in 1862." Despite, then, the great work of Clerk Maxwell and the corroborative

experiments of Hertz, we must still admit that the ultimate nature of electricity remains wrapped in mystery. It is true, we discard the material effluvium of Gilbert, but only to substitute for it an ethereal ripple, a quiver, a wave motion in the hypothetical ether with which we fill all space.

From 1580 to 1600, we find Gilbert spending in his workship all the leisure he can snatch from his professional duties. He notes down his experiments, his failures as well as his successes, discusses them, reasons on them, and pursues his inquiry further and further. In a word, we find him toiling in his workshop at Colchester as Faraday toiled more than 200 years later in the low, dark rooms of the Royal Institution of Great Britain. Both were actuated by the same calm, persevering, experimental spirit. Gilbert founded and christened the science of electrics; he left it in its infancy, it is true; but with sufficient vitality to enable it to survive the neglect of years, until at last it was taken up and fondly cared for by our Franklins and Faradays.

III.

The science of magnetism is even more indebted to Gilbert than that of electricity. The ancients spoke of the lodestone as the Magnesian stone, from its being found in Magnesia, in Asia Minor. Gilbert constantly uses the adjective *magnetica;* and it is to his use of that word that we owe the terms magnet, magnetic and magnetism.* He showed that a great number of bodies could be electrified; but he maintained that those only could exhibit magnetic properties which contain iron. He satisfies himself of this by rubbing with a lodestone such substances as wood, gold, silver, copper, zinc, lead, glass, etc., and then floating them on corks, quaintly adding that they show 'no poles, because the energy of the lodestone has no entrance into their interior.'

To-day we know that nickel and cobalt behave like iron, whilst antimony, bismuth, copper, silver and gold are susceptible of being influenced by powerful electromagnets, showing what has been termed diamagnetic phenomena. Even liquids and gases, in Faraday's classical experiments, yielded to the influence of his great magnet; and Professor Dewar, in the same Royal Institution, exposed some of his liquid air and liquid oxygen in the presence of the writer to the influence of Faraday's electromagnet and found them to be strongly attracted, thus behaving like the paramagnetic bodies, iron, nickel and cobalt.

Gilbert observes in all his magnets two points, one near each end, in which the force, or, as he terms it, 'the supreme attractional power,' is concentrated. He terms these *poles* by analogy to the earth; and he will have it understood that these poles are not mathematical points, as

* According to Humboldt, "the barbarous word *magnetismus*" was introduced in the eighteenth century.

the attraction manifests itself 'all over the periphery.' Following the same analogy, he calls the line joining the two poles the axis of the magnet, and the equator the line equally distant from them. With the aid of his steel versorium, he recognizes that similar poles are mutually hostile, whilst opposite poles seize and hold each other in friendly embrace. He also satisfies himself that the energy of magnets resides not only in their extremities, but that it permeates 'their inmost parts, being entire in the whole and entire in each part.' This is exactly what we say; it is nothing else than the molecular theory proposed by Weber, extended by Ewing and universally accepted.

At any rate, Gilbert is quite certain that whatever magnetism may be, it is not, like electricity, a material, ponderable substance; he ascertained this by weighing in the most accurate scales of a goldsmith a rod of iron before and after it had been rubbed with the lodestone, and then observing that the weight is precisely the same in both cases, being 'neither less nor more.' He discovers also that not only the magnet, but all the space surrounding it, possesses magnetic properties; for the magnet 'sends its force abroad in all directions, according to its energy and quality.' This region of influence he calls *orbis virtutis*, a sphere, or, as we call it, a field of force. With wonderful intuition, he sees this space filled with lines of magnetic virtue passing out radially from his spherical lodestone, and he calls these lines *radii virtutis magneticae*, rays of magnetic force.

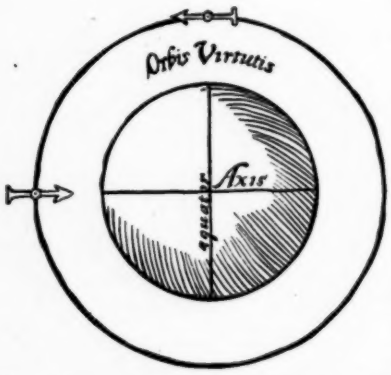

FIG. 1. GILBERT'S SPHERICAL LODESTONE AND FIELD OF MAGNETIC FORCE.

When Faraday spoke of field of force, magnetic field, lines of electric and magnetic induction, some thought the idea new, whereas not only the idea, but also the very terms occur with appropriate illustrations in De *Magnete*.

Clerk Maxwell was so fascinated with that beautiful concept that he made it the work of his life to study the field of force due to electrified bodies, to magnets and to conductors conveying currents; his powerful intellect visualized those lines and gave them accurate mathematical expression in the great treatise on electricity and magnetism which he gave to the world in 1873.

Gilbert observes that the lodestone may be spherical or oblong; 'whatever the shape, imperfect or irregular, verticity is present, there are poles,' and the lodestones 'have the selfsame way of turning to the poles of the world.' We find Gilbert working even with a ring of iron. He

strokes it with a natural magnet and feels certain that he has magnetized it; and he assures us that 'one of the poles will be at the point rubbed and the other will be at the opposite side;' and how does he convince himself that the ring is really magnetized? He cuts it across at the point opposite the one rubbed, opens it out, and finds that the ends exhibit polar properties.

A favorite piece of apparatus with Gilbert was a lodestone ground down into globular form. He called it a terrella, a miniature earth. He used it extensively for reproducing the phenomena described by magnetizers, travelers and navigators as observed in their compass needles. He breaks up terrellas, in order to examine the magnetic condition of their inner parts. There is not a doubtful utterance in his description of what he finds; he speaks clearly and emphatically. "If magnetic bodies be divided, or in any way broken up, each several part hath a north and a south end;" *i. e.*, each part will be a complete magnet.

We find him also comparing magnets by what is known to us as the 'magnetometer method.' He brings the magnetized bars in turn near a compass needle and concludes that the magnet or the lodestone which is able to make the needle go round is the best and strongest. He also seeks to compare magnets by a process of weighing, similar to what is called, in laboratory parlance, the 'test-nail' method. He also inquires into the effect of heat upon his magnets, and finds that 'a lodestone subjected to any great heat loses some of its energy.' He applies a red-hot iron to a compass needle and notices that it 'stands still, not turning to the iron.' He thrusts a magnetized bar into the fire until it is red-hot and shows that it has lost all magnetic power. He does not stop at this remarkable discovery, for he proceeds to let his red-hot bars cool while lying in various positions, and he finds: (1) that the bar will acquire magnetic properties if it lie in the magnetic meridian; and (2) that it will acquire none if it lie east and west. These effects he rightly attributes to the inductive action of the earth.

Gilbert marks these and other experiments with marginal asterisks; small stars denoting minor and large ones important discoveries of his. There are in all 21 large and 178 small asterisks, as well as 84 illustrations in *De Magnete*. This implies a vast amount of original work, and forms no small contribution to the foundations of electric and magnetic science.

Gilbert clearly realized the phenomena and laws of magnetic induction. He tells us that "as soon as a bar of iron comes within the lodestone's sphere of influence, though it be at some distance from the lodestone itself, the iron changes instantly and has its form renewed; it was before dormant and inert; but now is quick and active." He hangs a nail from a lodestone; a second from the first, a third from the

second and so on—a well-known experiment, made every day for elementary classes. Nor is this all, for he interposes between his lodestone and a mass of iron thick boards, walls of pottery and marble, and even metals, and he finds that there is naught so solid as to do away with this force or to check it, save a plate of iron. All that can be added to this pregnant observation is that the plate of iron must be very thick in order to carry all the lines of force due to the magnet, and thus completely screen the space beyond.

But Gilbert is astonishing when he goes on to make thick boxes of gold, glass and marble, and suspending his needle within them, declares with excusable enthusiasm that regardless of the box which imprisons

FIG. 2. GILBERT HEATED AND HAMMERED BARS OF IRON IN THE MAGNETIC MERIDIAN, AND ALLOWED THEM TO COOL WHILE LYING NORTH (*Septentrio*) AND SOUTH (*Auster*).

the magnet, it turns to its predestined points of north and south. He even constructs a box of iron, places his magnet within, observes its behavior, and concludes that it turns north and south, and would do so were 'it shut up in iron vaults sufficiently roomy.' Our experiments show that if the sides of the box are thin, the needle will experience the directive force of the earth; but if they are sufficiently thick—thick as the walls of an ordinary safe—the inside of such a box will be completely screened; none of the earth's magnetic lines will get into it so that the needle will remain indifferently in any position in which it is placed. A few years ago, the physical laboratory of St. John's College, Oxford, was screened from the obtrusive lines of neighboring dynamos

by building two brick walls parallel to each other and eight inches apart and filling in the space with scrap iron. A delicate magnetometer showed that this structure allowed no leakage of lines of force through it, but offered an impenetrable barrier to the magnetic influence of the working dynamos.

Gilbert's greatest discovery is that the earth itself is a vast globular magnet. 'Magnus magnes ipse est globus terrestris' are his own words. It has its poles, its axis and equator just as the lodestone or terrella. The pole in our hemisphere he variously calls north, boreal, arctic, whilst that in the other hemisphere he calls south, austral, antarctic. He is quite aware that his theory is a grand generalization; and admits that it is 'a new and till now unheard-of view,' and so confident is he in its worth that he is not afraid to say that 'it will stand as firm as aught that ever was produced in philosophy, backed by ingenious argumentation or buttressed by mathematical demonstration.' Three hundred years have passed away, and Gilbert's theory is accepted by every man of science and is taught in every school of physics. Moreover, save the correction of a few errors of observation, no change of any importance has been made in it.

Gilbert sought to explain the magnetic condition of our globe by the presence, especially in its innermost parts, of what he calls true terrene matter, homogeneous in structure and endowed with magnetic properties, so that every separate fragment of the earth exhibits the whole force of magnetic matter. We attribute terrestrial magnetism to the vast masses of magnetic material which lie near the surface, for at a depth of ten or twelve miles the temperature of the ferruginous masses would deprive them of all magnetic properties. The magnetic condition of the earth is also attributed to the action of electric currents continually flowing through the crust of the earth. Both these theories, as Professor Rücker, of London, said in 1891, are beset with difficulties; at present we must content ourselves with accumulating facts in the hope that a clue to an explanation may hereafter be found.

Gilbert's discovery enabled him to offer a philosophical explanation of the behavior of both compass and dipping needles, as well as of a great many other phenomena. The declination was known before Gilbert's time. Columbus noticed this want of coincidence between the geographical and magnetic meridians in his first voyage to the New World. It was on September 13, 1492, when 200 leagues west of Teneriffe, that his attentive eye observed that the magnet pointed slightly west of north, and that this angular deviation increased during the following days.* For a time he kept the secret in his own mind; the pilots, however, soon perceived the variations and grew alarmed, deserted, as

* Columbus was thus the first to observe that the declination or 'variation of the compass,' as it is called, changes with place.

they said they were, on the trackless ocean by their only trusty guide. Columbus calmed their fears by saying that the needle did not turn to the polar star, but to some fixed and invariable point near it. This explanation, born of inspiration, quieted the sailors, who marveled much at the Admiral's great astronomical knowledge. Gilbert rightly states that the declination changes with place, but he slips into error when he says: "As the needle hath ever inclined towards east or towards west, so even now does the arc of variation continue to be the same in whatever place or region, be it sea or continent; so, too, will it be forever unchanging."

We know, however, that for any given place this angle is continuously, though slowly, changing. Some of these changes require centuries for the completion of their cycle, and are therefore called 'secular'; others require but a year, and are termed 'annual'; whilst others run their course in the space of a day and are known as 'diurnal.' Though these periodic changes in the declination have been established by careful and prolonged observations, we can not say that they are yet satisfactorily accounted for.

The dip of the needle was also familiar to Gilbert, having been first observed in 1576 by Robert Norman. Our philosopher illustrates this phenomenon by balancing a piece of steel so that it remains exactly horizontal when unmagnetized, and by observing that the moment it is stroked by a magnet its north-seeking end dips 'as low as the fulcrum on which it is supported permits.' Gilbert moves a needle over his terella, and finds (1) that the dip is 0° on the equator, (2) that it gradually increases with the latitude being 90° at either pole.

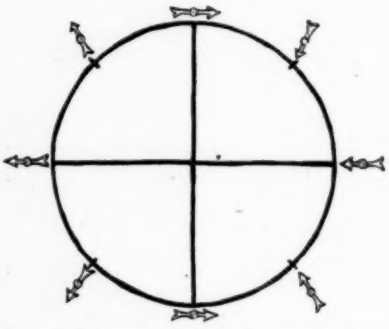

FIG. 3. GILBERT'S TERELLA SHOWING THE BEHAVIOR OF A DIPPING-NEEDLE AT ITS POLES, EQUATOR AND OTHER INTERVENING PLACES.

He extends this experiment from the terrella to the earth itself, and even devises an instrument for determining the latitude of any place on land or on sea in the thickest weather and in the darkest night, 'without the help of sunne, moone, or starre.' In this, however, he was wrong. For he assumed the isoclinic lines to be circles running parallel to the magnetic equator, which he erroneously supposed to coincide with the geogrpahical equator.

Gilbert recognized that the earth exerts on a freely movable needle a force that gives it direction and not a motion of translation. He illustrates this by floating a needle on a cork and observing that it points

N. and S., remaining all the while at any place in the vessel of water in which it may be put. His words, though quaint, are exact: "It revolves on its iron center, and is not borne towards the rim of the vessel." He knew nothing of the mechanical couple in play; but he knew the fact; and with the instinct of a true philosopher, tested it in a variety of ways. With a most luminous insight into terrestrial magnetic phenomena, he observed that near the poles a compass needle tending, as it does, to dip greatly, must necessarily experience only a feeble horizontal directive force. To this he adds that 'at the poles there is no direction,' meaning thereby that a properly balanced compass needle

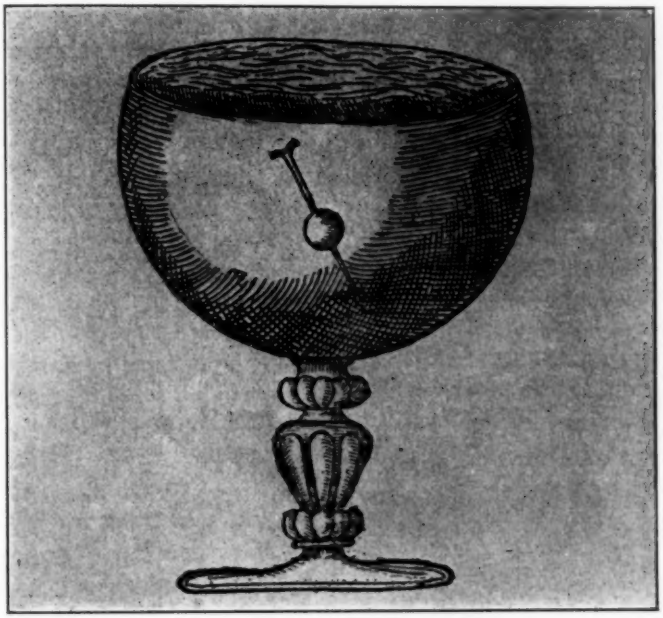

FIG. 4. GILBERT'S METHOD OF SHOWING MAGNETIC DIP.

would remain indifferently in any azimuth in which it might be placed. We express the same by saying that the horizontal component of the earth's force vanishes at the poles.

Gilbert dwells at length on the inductive action of the earth. We have seen him hammering heated bars of iron and then allowing them to cool while lying in the magnetic meridian. He notes that they become magnetized, and does not fail to point out the polarity of each end. He likewise attributes to the influence of the earth the magnetic condition acquired by iron bars that have for a long time lain fixed in the north and south position as bars often are fixed in buildings and in windows, and he ingenuously adds: for great is the effect of long-con-

tinued direction of a body towards the poles. To the same cause he attributes the magnetization of iron crosses fixed to steeples, towers, etc.

It must be evident from this brief analysis of *De Magnete*,

1. That Gilbert was acquainted with all the facts in magnetism known in his days;

2. That he added profusely to the number;

3. That he coordinated these facts and deduced the laws which govern them; and

4. That he was the first to offer a scientific explanation of the behavior of the compass and the dip needle, as well as of numerous other phenomena, correctly attributed by him to the magnetic state of our globe.

Such were some of the 'rowing pins,' as Chancellor Bacon ironically calls them, with which Gilbert built up one of the greatest monuments ever erected by the genius of one man. Had Gilbert done nothing else than propound and establish on the solid basis of observation and experiment his theory that the earth is a great magnet, his name would ever live in the annals of science, surrounded with a halo that even the unjust strictures of Bacon could not dim; but when we consider his spirited advocacy of research at the end of the sixteenth century, and the cardinal advances he achieved in the interpretation of two great branches of knowledge, we can have no hesitation in considering him with Poggendorff, 'the Galileo of Magnetism,' and with Priestley, 'the Founder of Modern Electricity.'

Were we asked to write an inscription for his statue, we should write the simple words:

Gilbert, the Columbus of the Electrical World.

THE PEOPLING OF THE PHILIPPINES.

By PROFESSOR RUD. VIRCHOW.

PART II.*

When, on the 18th of March, 1897, I made a communication on the population of the Philippines, a bloody uprising had broken out everywhere against the existing Spanish rule. In this uprising a certain portion of the population, and indeed that which had the most valid claim to aboriginality, the so-called Negritos, was not involved. Their isolation, their lack of every sort of political, often indeed of village organization, also their meager numbers, render it conceivable that the greatest changes might go on among their neighbors without their taking such a practical view of them as to lead to their engaging in them. Thus it can be understood how they would take no interest in the further development of the affair.

Since then the result of the war between Spain and the United States has been the destruction of Spanish power, and the treaty of Paris brought the entire Philippine Archipelago into the possession of the United States of America. Henceforth the principal interest is centered upon the deportment of the insurgents, who have not only outlived the great war between the powers, but are now determined to assert, or win, their independence from the conquerors. These insurgents, who for brevity are called Filipinos, belong, as I have remarked, to the light-colored race of so-called Indios, who are sharply differentiated from the Negritos. Their ethnological position is difficult to fix, since numerous mixtures have taken place with immigrant whites, especially with Spaniards, but also with people of yellow and of brown races—that is, with Mongols and Chinese.† Perhaps here and there the importance of this mixture on the composite type of the Indios has been overestimated; at least in most places positive proof is not forthcoming that foreign blood has imposed itself upon the bright-colored population. Both history and tradition teach, on the contrary, as also the study of the physical peculiarities of the people, that among the various tribes differences exist which suggest family traits. To this effect is the testimony of several travelers who have followed one

* Sitzungsberichte der Königlichen Preussischen Akademie der Wissenschaften zu Berlin. Berlin, 1899, Vol. III, 19th January, pp. 14-26.

† NOTE.—A brief résumé of these many mixtures is given in Tour du Monde, 27th May and 3d June, 1882; see also statement in this translation. —TRANSLATOR.

another during a long period of time, as has been developed especially by Blumentritt.

In this connection it must not be overlooked that all these immigrations, howsoever many they be supposed to have been, must have come this way from the west. Indeed, a noteworthy migration from the east is entirely barred out, if we look no farther back than the Chinese and Japanese. On the contrary, all signs point to the assumption that from of old, long before the coming of Portuguese and Spaniards, a strong movement had gone on from this region to the east, and that the great sea way which exists between Mindanao and the Sulu islands on the north and Halmahera and the Moluccas on the south was the entrance road along which those tribes, or at least those navigators whose arrival peopled the Polynesian Islands, found their way into the Pacific Ocean. But also the movement of the Polynesians points to the west, and if their ancestors may have come from Indonesia there is no doubt that in their long journeys eastward they must have touched at the coasts of other islands on their way, especially the Philippines. Polynesian invasions of the Philippines are not supposed to have closed when a migration of peoples or of men passing out to the Pacific Ocean laid the foundation of a large fraction of the population of the archipelago. It is known that now and then single canoes from the Palawan or the Ladrone islands were driven upon the east coast of Luzon, but their importance ought not to be overestimated. The migration this way from the west must henceforth remain as the point of departure for all explanations of this eastern ethnology.

[These statements are well enough for working hypotheses, but actual proofs are not at hand. Ratzel, Berl. Verhandl., etc., Phil. Hist. Class, 1898, I, p. 33.—TRANSLATOR.]

Now, how are the local differences of various tribes to be explained, when on the whole the place of origin was the same? Is there here a secondary variation of the type, something brought about through climate, food, circumstances? It is a large theme, which, unfortunately, is too often dominated by previously-formed theories. The importance of 'environment' and mode of life upon the corporeal development of man can not be contested, but the measure of this importance is very much in doubt. Nowhere is this measure, at least in the present consideration, less known than in the Philippines. In spite of wide geological and biological differences on these islands, there exists a close anthropological agreement of the Indios in the chief characteristics, and the effort to trace back the tribal differences that have been marked to climatic and alimentary causes has not succeeded. The influence of inherited peculiarities is also more mighty here, as in most parts of the earth, than that of 'milieu.'

If we assume, first, that the immigrants brought their peculiarities with them, which were fixed already when they came, we must also accept as self-evident that the Negritos of the Philippines do not belong to the same stock as the more powerful, bright-colored Indios. As long as these islands have been known, more than three centuries, the skin of the Negritos has been dark brown, almost black, their hair short and spirally twisted, and just as long has the skin of the Indios been brownish, in various shades, relatively clear, and the hair has been long and arranged in wavy locks. At no time, so far as known, has it been discovered that among a single family a pronounced variation from these peculiarities had taken place. On this point there is entire unanimity. In case of the Negritos there is not the least doubt; of the Indios a doubt may arise, for, in fact, the shades of skin color appear greatly varied, since the brown is at times quite blackish, at times yellowish, almost as varied as is the color of the sunburnt hair. But even then the practised eye easily detects the descent, and if the skin alone is not sufficient the first glance at the hair completes the diagnosis. The correct explanation of individual or tribal variations is difficult only with the Indios, while no such necessity exists in the case of the Negritos. But among the Indios these individual and tribal variations are so frequent and so outspoken that one is justified in making the inquiry whether there has not developed here a new type of inherited peculiarities. If this were the case, it must still be held that already the immigrant tribes had possessed them.

Now, history records that different immigrations have actually taken place. Laying aside the latest before the arrival of the Spaniards, that of the Islamites, in the fourteenth and fifteenth centuries, there remains the older one. If ethnologists and travelers in general come to the conclusion concerning Borneo—and it is to be taken as certain—that the differences now existing among the wild tribes of this island are very old, it ought not be thought so wonderful if, according to the conditions of the tribes which have immigrated thence, there should exist on the Philippines near one another dissimilar though related peoples. This difference is not difficult to recognize in manners and customs—a side of the discussion which is further on to be treated more fully. We begin with physical characteristics.

Among these the hair occupies the chief place. To be sure, among all the Indios it is black, but it shows not the slightest approach to the frizzled condition which is such a prominent feature in the external appearance of the Negritos and of all the Papuan tribes of the East. This frizzled condition may be called woolly, or in somewhat exaggerated refinement in the name may be attributed to the term 'wool,' all sorts of meanings akin to wool; in every case there is wanting to all the Indios the crinkling of the hair from its exit out

of the follicle, whereby would result wide or narrow spiral tubes and the coarse appearance of the so-called 'peppercorn.' The hair of all Indios is smooth and straightened out, and when it forms curves they are only feeble, and they make the whole outward appearance wavy or, at most, curled.

But within this wavy or curled condition of the hair there are again differences. In my former communication I called attention to examinations which I made upon a large number of islands in the Malay Sea, and in which it was shown that a certain area exists which begins with the Moluccas and extends to the Sunda group, in which the hair shows a strong inclination to form wavy locks, indeed passes gradually into crinkled, if not into spiral, rolls. Such hair is found specially in the interior of the islands, where the so-called aboriginal population is purer and where for a long time the name of Alfuros* has been conferred on them. On most points affinity with Negritos or Papuans is not to be recognized. Should such at any time have existed, we are a long way from the period when the direct causes thereof are to be looked for. In this connection the study of the Philippines is rich with instruction. In the limits of the almost insular, isolated Negrito enclave, mixtures between Negritos and Indios very seldom surprise one, and never the transitions that can have arisen in the post-generative time of development. [The island of Negros, on the contrary, is peopled by such crossbreeds.—TRANSLATOR.]

If there are among the bright-colored islanders of the Indian Ocean Alfuros and Malays close together there is nothing against coming upon this contrast in the Philippine population also. Among the more central peoples the tribal differences are so great that almost every explorer stumbles on the question of mixture. There not only the Dayaks and the other Malays obtrude themselves, but also the Chinese and the Mongolian peoples of Farther India. Indeed, many facts are known, chiefly in the language,† the religion, the domestic arts, the agriculture, the pastoral life which remind one of known conditions peculiarly Indian. The results of the ethnologists are so tangled here that one has to be cautious when one or another of them draws conclusions concerning immigrations, because of certain local or territorial specializations. Of course, when a Brahmanic custom occurs anywhere it is right to conclude that it came here from India. But before assuming that the tribe in which such a custom prevails itself comes from Hither or Farther India, the time has to be ascer-

* On this objectionable name, see supra. That the term does not connote hair characters cf. A. B. Meyer, Sitzungsb. d. Phil. Hist. Classe der kaiserlichen Akademie der Wissensch. Wien, 1882, Vol. CI, p. 550.—TRANSLATOR.

† Don T. H. Pardo de Tavera, El sanscrito e la lengua tagalog. Paris, 1887.

tained to which the custom is to be traced back. The chronological evidence leads to the confident belief that the custom and the tribe immigrated together.

Over the whole Philippine Archipelago religious customs have changed with the progress of external relations. Christianity has in many places spread its peculiar customs, observances and opinions, and changed entirely the direction of thought. On closer view are to be detected in the midst of Christian activities older survivals, as ingredients of belief which, in spite of that religion, have not vanished. Before Christianity, in many places, Islam flourished, and it is not surprising to witness, as on Mindanao, Christian and Mohammedan beliefs side by side. But, before Islam, ancestor worship, as has long been known, was widely prevalent. In almost every locality, every hut has its Anito with its special place, its own dwelling; there are Anito pictures and images, certain trees and, indeed, certain animals in which some Anito resides. The ancestor worship is as old as history, for the discoverers of the Philippines found it in full bloom, and rightly has Blumentritt* characterized Anito worship as the ground form of Philippine religion. He has also furnished numerous examples of Anito cult surviving in Christian communities.

Chronology has a good groundwork and it will have to observe every footprint of vanishing creeds. Only, it must not be overlooked that the beginning of the chronology of religion has not been reached, and that the origin of the generally diffused ancestor worship, at least on the Philippines, is not known. If it is borne in mind that belief in Anitos is widely diffused in Polynesia and in purely Malay areas, the drawing of certain conclusions therefrom concerning the prehistory of the Philippines is to be despaired of.

Next to religious customs, among wild tribes fashions are most enduring. Little of costume is to be seen, indeed, among them. Therefore, here tattooing asserts its sway. The more it has been studied in late years the more valuable has been the information in deciding the kinship relations of tribes. Unfortunately, in the Philippines the greater part of the early tattoo designs have been lost, and the art itself is also nearly eliminated. But since the journey of Carl Semper† it has been known that not only Malays but also Negritos tattoo; indeed, this admirable explorer has decided that the 'Negroes of the East Coast' practise a different method of tattooing from that of the Marivales in the west, and on that account they attain different results. In the one case a needle is employed to make fine holes in the skin in

* Der Ahnencultus und die religiösen Anschauungen der Malaien des Philippinen-Archipels. Wien, 1882, p. 2. (From Mittheil. der K. K. Geograph. Gesellschaft).

† Die Philippinen und ihre Bewohner. Würzburg, 1869, pp. 50, 137.

which to introduce the color; in the other long gashes are made. In the latter case prominent scars result; in the former a smooth pattern. But these combined patterns are on the whole the same, instead of rectilinear figures. Schadenburg has the operations commence with a sharpened bamboo on children 10 years of age.* Among the wild tribes of the light-colored population tattooing is not less diffused, but the patterns are not alike in the different tribes. Isabelo de los Reyes reports that† the Tinguianes, who inhabit the mountain forests of the northern cordilleras of Luzon, produce figures of stars, snakes, birds, etc., on children 7 to 9 years old. Hans Meyer describes the patterns of the Igorrotes.‡ There appears to exist a great variety of symbols; for example, on the arms, straight and crooked lines crossing one another; on the breast, feather-like patterns. Least frequently he saw the so-called Burik designs, which extended in parallel bands across the breast, the back, and calves, and give to the body the appearance of a sailor's striped jacket. It is very remarkable that the human form never occurs.

What is true concerning tattooing on so many Polynesian islands holds also completely here. But reliable descriptions are so few, and especially there is such a meager number of useful drawings, that it would not repay the trouble to assemble the scattered data. At least it will suffice to discover whether among them there are genuine tribal marks or to investigate concerning the distribution of separate patterns. Those known show conclusively that in the matter of tattooing the Filipinos are not differentiated from the islanders of the Pacific; they form, moreover, an important link in the chain of knowledge which demonstrates the genetic homogeneity of the inhabitants. The tattooings of the eastern islanders are comparable only to those of African aborigines, with which last they furnish many family marks, made out and recognized. It is desirable that a trustworthy collection of all patterns be made before the method becomes more altered or destroyed.

Next to the skin, among the wild tribes the teeth are modified in the most numerous artificial alterations. The preferable custom, common in Africa, of breaking out the front teeth in greater or less number has not, so far as I remember, been described among the Filipinos; I only mention that while I was making a revision of our Philippine crania, two of them turned up in which the middle upper incisors had evidently been broken out for a long time, for the alveolar border had shrunk into a small quite smooth ridge, without a trace of an alveolus. It is otherwise with the pointing of the incisors, especially the upper

* Zeitschrift für Ethnologie, 1880, XII, p. 136.

† Die Tinguianen (Luzon). Translated from the Spanish by F. Blumentritt (Mitth. der K. K. Geograph. Ges. in Wien), 1887.

‡ Verhandl. der Berliner Gesellsch. für Anthropologie, 1883, p. 380.

ones, which, also, is not common. I must leave it undecided whether the sharpening is done by filing or by breaking off pieces from the sides. The latter should be in general far more frequent. In every case the otherwise broad and flat teeth are brought to such sharp points as to project like those of the carnivorous animals. I have met with this condition several times on Negrito skulls and furnished illustrations of them.* On a Zambal skull, excavated by Dr. A. B. Meyer and which I lay before you, the deformation is easy to be seen. I called attention at the time to the fact that among the Malays an entirely different method of modifying the teeth is in vogue, in which a horizontal filing on the front surface is practised and the sharp lower edge is straightened and widened. Already the elder Thévenot has accentuated this contrast when he says:

"These cause the teeth to be equal, those file them to points, giving them the shape of a saw."†

This difference appears to have held on till the present; at least no skull of an Indio is known to me with similar deformation of the teeth. This custom of the Negritos is so much more remarkable since the chipping of the corners of the teeth is widely spread among the African blacks.

The other part of the body used most for deformation—the skull—is in strong contrast to the last-named custom. Deformed crania, especially from older times, are quite numerous in the Philippines; probably they belong exclusively to the Indios. If they exist among the Negritos, I do not know it; the only exception comes from the Tinguianes, of whom J. de los Reyes reports their skulls are flattened behind (por detrás oprimido). Such flattening is found, however, not seldom among tribes who have the practise of binding children on hard cradle boards—chiefly among those families who keep their infants a long time on such contrivances. A sure mark by which to discriminate accidental pressure of this sort from one intentionally produced is not at hand; it may be that in accidental deformation oblique position of the deformed spot is more frequent; at any rate, the difference in the Philippines is a very striking one, since there not so much the occiput as the front and middle portions suffer from the disfigurements, and thereby deformations are produced that have had their most perfect expression among the ancient Peruvians and other American tribes.

I have discussed cranial deformation of the Americans in greater detail, where I exhibit the accidental and the artificial (intentional)

* Abhandlung über alte und neue Schädel, in F. Jagor's Reisen in den Philippinen. Berlin, 1873, p. 374, Pl. II, figs. 4 and 5.

† G. A. Baer (Verhandl. d. Berliner Anthrop. Gesellschaft, 1879, p. 331) says that such an operation obtains only among Negritos of pure blood.

deformation in their principal forms.* The result is that in large sections of America scarcely any ancient skulls are found having their natural forms, but that the practise of deformation has not been general; moreover, a number of deformation centers may be differentiated which stand in no direct association with one another. The Peruvian center is far removed from that of the northwest coast, and this again from that of the Gulf States. From this it must not be said that each center may have had its own, as it were, autochthonous origin. But the method has not so spread that its course can be followed immediately. Rather is the supposition confirmed that the method is to be traced to some other time, therefore that somewhere there must have been a place of origin for it. On the Eastern Hemisphere, and especially in the region here under consideration, the relations are apparently otherwise. Here exist, so far as known, great areas entirely free from deformation; small ones, on the other hand, full of it. There are here, also, deformation centers, but only a few. Among these, with our present knowledge, the Philippines occupy the first place.

The knowledge of this, indeed, is not of long duration. Public attention was first aroused about thirty years ago concerning skulls from Samar and Luzon, gathered by F. Jagor from ancient caves, to furnish the proof of their deformation. Up to that time next to nothing was known of deformed crania in the oriental island world. First through my publication† the attention of J. G. Riedel, a most observant Dutch resident, was called to the fact that cranial deformation is still practised in the Celebes, and he was so good as to send us a specimen of the compressing apparatus for infants (1874).‡ Compressed crania were also found. But the number was small and the compression of the separate specimens was only slight. In both respects what was observed in the Sunda islands did not differ from the state of the case in the Philippines. Through Jagor's collections different places had become known where deformed crania were buried. Since then the number of localities has multiplied. I shall mention only two, on account of their peculiar position. One is Cagraray, a small island east of Luzon, in the Pacific Ocean, at the entrance of the Bay of Albay;§ the other, the island of Marinduque, in the west, between Luzon and Mindoro. From the last-named island I saw, ten years ago, the first picture of one in a photograph album accidentally

* Crania ethnica Americana. Berlin, 1892, p. 5, and figs.

† Zeitschr. für Ethnologie, 1870, Vol. II, p. 151.

‡ The same, III, p. 110, Pl. V, fig. 1; Verhandl. Anthrop. Ges., Vol. VI, p. 215; Vol. VII, p. 11; Vol. VIII, p. 69; Vol. IX, p. 276.

§ Verhandl. der Berliner Anthrop. Gesellsch., 1879, Vol. XI, p. 422; 1889, Vol. XXI, p. 49.

placed in my hands. Since then I had opportunity to examine the Schadenberg collection of crania, lately come into the possession of the Reichsmuseum, in Leyden, and to my great delight discovered in it a series of skulls which are compressed in exactly the same fashion as those of Lanang. It is said that these will soon be described in a publication.

It is of especial interest that this method has been noted in the Philippines for more than three hundred years. In my first publication I cited a passage in Thévenot where he says, on the testimony of a priest, that the natives on some islands had the custom of compressing the head of a newborn child between two boards, so that it would be no longer round, but lengthened out; also they flattened the forehead, which they looked upon as a special mark of beauty. This is, therefore, an ancient example. It is confirmed by the circumstance that these crania are found especially in caves, from the roofs of which mineral waters have dripped, which have overlaid the bones partly with a thick layer of calcareous matter. The bones themselves have an uncommonly thick, almost ivory, fossil-like appearance. Only the outer surface is in places corroded, and on these places saturated with a greenish infiltration. It is to be assumed, therefore, that they are very old. I have the impression that they must have been placed here before the discovery of the islands and the introduction of Christianity. Their peculiar appearance, especially their angular form and the thickness of the bone, reminds one of crania from other parts of the South Sea, especially those from Chatham and Sandwich Islands. I shall not here go further into this question, but merely mention that I came to the conclusion that these people must be looked upon as proto-Malayan.

The changes which will take place in the political condition of the Philippines may be of little service to scientific exploration at first; but the study of the population will be surely taken up with renewed energy. Already in America scholars have begun to occupy themselves therewith. A brief article by Dr. Brinton is to be mentioned as the first sign of this.* But should the ardent desire of the Filipinos be realized, that their islands should have political autonomy, it is to be hoped that, out of the patriotic enthusiasm of the population and the scientific spirit of many of their best men, new sources of information will be opened for the history and the development of oriental peoples. To this end it may be here mentioned, by the way, that the connecting links of ancient Philippine history and the customs of these islands, as well with the Melanesians as with the Polynesians of the south, are yet to be discovered.

* The Peoples of the Philippines, Washington, D. C., 1898. American Anthropologist.

As representatives of these two groups, I present, in closing, two especially well-formed crania from the Philippines. One of them, which shows the marks of antiquity that I have set forth, belongs to an Indio. It has the high cranial capacity of 1,540 cubic centimeters, a horizontal circumference of 525 millimeters, and a sagittal circumference of 386 millimeters; its form is hypsidolicho, quite on the border of mesocephaly: Index of width, 75.3; index of height, 76.3. Besides, it has the appearance of a race capable of development; only, the nose is platyrrhine (index, 52.3), as among so many Malay tribes, and in the left temple it bears a *Processus frontalis squamae temporalis* developed partly from an enlarged fontanelle. The other skull was taken from a Negrito grave of Zambales by Dr. A. B. Meyer. It makes, at first glance, just as favorable an impression, but its capacity is only 1,182 cubic centimeters; therefore 358 cubic centimeters less than the other. Its form is orthobrachycephalic; breadth index, 80.2; height index, 70.6. As in single traits of development, so in the measurements, the difference and the debased character of this race obtrude themselves. Only, the nasal index is somewhat smaller; on the whole, the nose has in its separate parts a decidedly pithecoid form.

SCIENCE AND PHILOSOPHY.

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WHETHER the average man recognize the situation or palter with it, there can be no doubt that a dualism, a separation, if not an antagonism, between science and religion forms one conspicuous phenomenon of modern life. True, palliating circumstances may have eased or disguised it somewhat in recent years. But palliation was always a makeshift, and, everything considered, the fundamental opposition remains, little mitigated. Of course, we may allege that religion and theology are by no means identical, and that the latter rather than the former withstands scientific views and conclusions. Yet, when we summon courage to be quite frank with ourselves, we must admit freely that religion, as an organized social factor, is so bound up with theological presuppositions as to render this distinction more of a subterfuge than a solution. Again, many in these days seem to think that another marked contrariety of interest characterizes the relation between science and philosophy. And, indeed, one must admit that, altogether apart from theoretical problems, certain features of the academic world, in such countries as Scotland and the United States, for example, afford basis for this prevalent opinion. In the Scottish universities one-half of the professors of philosophy are clergymen. In the universities and colleges of the United States the theological affiliations are even more intimate. Speaking from memory, I recall that in only three of our nine leading universities do we find the philosophical departments free from clerical influence, while, in the lesser institutions, clerical control constitutes the rule, not the exception. Small wonder, then, if many have identified the tendencies of philosophy with the theological, as opposed to the scientific, side of contemporary controversy.

But, if manifold causes thus support the view that science and philosophy must necessarily conflict, there happen to be other aspects of the matter well worth consideration. In Germany, for instance, the home land of philosophical inquiry during the nineteenth century, the progress of science has been exercising decisive influence on speculative thought for a generation at least. Furthermore, the rise and development of experimental psychology has induced many, whose main work lies on the philosophical rather than on the scientific side

of the fence, to familiarize themselves with the scientific attitude and temper, while the gradual entry of the sciences into the usual undergraduate course at our colleges has not left the earlier education of those who come afterwards to specialize in philosophy so utterly void of scientific knowledge as it used to be. Moreover, the long commerce of our ablest students with German culture cannot but have produced similar modifications. Be this as it may, the point I desire to emphasize is that no conflict can exist properly between science and philosophy, and that a most interesting—possibly the most hopeful—trait of recent thought may be traced precisely in the inclination towards an alliance. It ought to be said, too, that some few, whose work appears to lie in the immediate future—to present symptoms of decided vitality—tend clearly in this direction. And, when we stay to reflect for a moment, why should it not be so? Science and philosophy possess this in common—they search for the truth free from all trammels of dogmatic presupposition. If they prove true to themselves, their object must be the same, even if they view it from different sides and for different purposes. Take them from what standpoint you please, both are 'science' in the broad sense of the untranslatable term, *Wissenschaft*. It may be of interest, therefore, to devote some attention to the new-old question, What is the relation between science and philosophy?

Approaching the problem historically, it proves something of a shock to learn that the so-called opposition had no existence seventy years ago. Nay, from the time of Descartes' 'Discours de la Méthode' (1637) till the enunciation of the cellular theory (Schleiden and Schwann, *c.* 1838), free interaction, often conscious cooperation, prevailed. Recall the full title of Descartes' epoch-making tractate, 'Discours de la Méthode pour bien conduires sa raison, et chercher la vérité dans les sciences; plus la Dioptrique, les Météores et la Géométrie, qui sont des Essais de cette Méthode'; recall Spinoza, the optician; recall Leibnitz and his calculus; recall the sober, scientific temper of the entire British school, from Hobbes to Hume; recall Kant's cosmogony, the precursor of modern ethereal physics, and remember that the critical philosopher likened himself, not to Plato or Bacon, but to Copernicus; you find no ground for controversy, but every symptom of mutual good-will. The contrast between this two hundred years' truce, covering the history of thought from the Reformation till the French Revolution, and the undignified, profitless squabbles, still fresh in the memory of many middle-aged men, is so striking that a call for reasons goes forth at once. If this matter can be elucidated, much will have been done to *explain away* the recent unfriendliness. At the same time, the case presents peculiar difficulties, because the evolution of thought in this connection furnishes

one among the great paradoxes of history. Ever fond of revenges, the Time-spirit becomes supremely ironical here.

Post-Reformation Europe accomplished much for science and philosophy. In both fields, investigation followed clearly marked lines, but the conclusions reached were of such a nature that they dovetailed easily. For science meant the mathematico-physical sciences, specifically, mathematics, astronomy and 'molar' physics. Philosophy meant, on the continent, the metaphysics of dualism, starting from the question, How can matter and mind, extension and thought, as they were then termed, be related so as to form a consistent whole; in Britain, individualistic psychology, concentrated on the problem, How do I get knowledge, and, when obtained, what is it? In a word, the sciences and philosophy attacked the same universe—the universe as conceived by Newton. Philosophy did not aspire to a higher knowledge than that reached by science, but confined its inquiries to some aspects of the world which had been left untouched by mathematics and physics. Thus both arrived at consonant conclusions. Harvey, for example, did not suggest that Bacon wrote on scientific questions like a philosopher, as he would assuredly have done had they lived forty years ago; he said merely, the Lord Chancellor writes like a Lord Chancellor—a lawyer of assured position.

The general view of the universe then held by scientific men supplied the framework within which the philosophers labored; it did not occur to the metaphysicians that the modes of thought in which this universe was conceived could be subjected to fundamental criticism. What, next, was this view? Briefly, it may be called static, molar and mechanical in the strictest sense of the word mechanism. It dealt with *self-contained* bodies in equilibrium or at rest; with *self-contained* aggregations of matter capable of measurement; with the relations subsisting between *self-contained* wholes; that is, with external connection, not with internal self-manifestation. As time passed, this general conception of things became more and more firmly rooted, thanks to Newton's genius. Indeed, it maintained itself with little change, especially in the English-speaking countries and in France, till forty-five years of the nineteenth century had winged their way. Whewell, in his great 'History of the Inductive Sciences' (1837-57), displays astonishing ignorance of the transformations that were afoot in his day—of Gauss and Weber on absolute measurements, of Schwann on the cell theory, of Mohl on protoplasm, of Mayer on heat, of Helmholtz on the conservation of energy, of Herapath on the mechanical theory of gases and the like. If the hold of the 'Newtonian philosophy' remained so strong at this date, we can infer readily how exclusive was its predominance in previous times. Now the theory of the universe contained in the *Principia* had a distinctively philosophical aspect

in so far as it was universal. Otherwise it presents few qualities to which we should attach this name at present. For the system contemplated the division of matter into separate parts, each of which occupied a place—a place subject to change, no doubt—in empty space, while to these circling orbs force was linked somehow. The relation between any two, therefore, can not be the result of inherent nature, but must follow from the interference of a cause external to the terms of the relation. Newton has put himself on decided record on this very question. In a letter to Bentley, written about the new year of 1693, he says: "It is inconceivable that inanimate brute matter should, without the mediation of something else, which is not material, operate upon and effect other matter without mutual contact, as it must be, if gravitation, in the sense of Epicurus, be essential and inherent in it. And this is one reason why I desired you would not ascribe innate gravity to me. That gravity should be innate, inherent and essential to matter, so that one body may act upon another at a distance through a *vacuum,* without the mediation of anything else, by and through which their action and force may be conveyed from one to the other, is to me so great an absurdity that I believe no man, who has in philosophical matters a competent faculty of thinking, can ever fall into it. Gravity must be caused by an agent acting constantly according to certain laws; but whether this agent be material or immaterial, I have left to the consideration of my readers." Summarily put, this means that the solar system is the type of universe, and it is a *system,* because 'an agent acting constantly according to certain laws' has rendered it such. And this implies, further, that, while a *description* of the universe may be possible, as in terms of mathematics, an *explanation* of it is beyond reach.

Turning to the philosophical side, a curious parallelism attracts notice at once. Of course, we are dealing no longer with 'heavenly bodies,' but matter and mind are treated by the philosophers exactly as Newton dealt with his material wholes. Descartes asks himself in effect, How is it that thought, which possesses none of the qualities of extension (matter) and extension, which possesses none of the qualities of thought, comes to unite so as to *be* a single whole in man's experience? He supposes that ideas are copies of things. But, even so, How do we know that the copies are correct or reasonably adequate? The solution can come by one answer alone. Some agent, which is neither an idea nor a thing, must vouch for the correspondence. Just as, in the physical world, one body can not affect another, except by the operation of a law-giving agent, so thought and extension can not be combined in our universe, except God have so willed it. The parallelism is precise. A 'third thing,' belonging neither to the sphere of intellect nor to that of the external world, must be assumed as the

basis of both. Here we meet that hoary sinner, the 'uncaused cause,' about which, to our modern amazement, the science and philosophy of that day are agreed entirely.

Passing to England, we find Locke confronted by a different problem, but the setting remains identical. Assuming, like Newton and Descartes, two separate factors—others assumed many, but the number makes no essential difference—and asking, How do I, who am inside, get my knowledge of things, which are outside? Under the circumstances, the obvious reply is, through the senses. The senses write upon the mind. Unfortunately, this information about the external world lacks directness, for the senses are modifications of the bodily organism and therefore tell nothing about the real objects. How, then, placed in such a dilemma, do we know objects? Locke alleges that Substance, a thing which we do not perceive, but which we are compelled to infer, originates the conviction of permanence associated with reality in objects. Here, once more, a third thing, belonging to neither of the factors under review, plays the part of Newton's agent and of the Cartesian deity. Without condescending upon further details, it is easy to see why science and philosophy could not well fall out during the period when such conceptions held sway. But this agreement, happy in its unconsciousness of problems at all events, was not to endure forever. The world of human experience revealed new aspects, and fresh questions, sources of dire controversy, loomed upon the horizon. The dynamic, molecular and organic modes of thought, with their attendant conception of the universe, were destined to elbow out the static and mechanical.

Even amid many seeming transformations, the 'Newtonian philosophy' preserved itself unchanged in essentials. The Deistic movement, Butler's 'Analogy,' Pope's 'Essay on Man' and Paley's 'Natural Theology,' and the highly wrought productions of the great French physicists, culminating in Laplace's 'Mécanique Céleste,' even the Scottish 'common-sense' protest against current scepticism, all emerged on the basis of its first principles. But, after the middle of the eighteenth century, three men shook it to its foundations and made possible the new structure we now call 'modern' thought. These men were Hume, Kant and Herder; the half-conscious protest of Spinoza had passed over the heads of his contemporaries unheeded. Was he not a Jew, a pantheist and, therefore, a flat blasphemer? The joint performance of this eighteenth century trinity, 'equal in power and glory,' raises problems of the most complicated kind, so complicated, indeed, that they have been the bugbear even of expert students during the last two generations. I can attempt here to put the salient points only, as clearly as possible.

Many pious efforts to understand Hume have been frustrated by

the idea that he was a dangerous sceptic, an infidel, a bold, bad man and what not. The simple truth happens to be that Hume found himself confronted by certain definite questions which had grown under the hands of his predecessors. In his case, the power of the man coincided with the power of the moment; and he still occupies his lonely pedestal as the single thinker of the first-class produced by the Anglo-Saxon race, because he settled the account of an age once for all. Had this been comprehended sooner, the nineteenth century would have been saved a wealth of waste paper and some lost temper. Reduced to its simplest elements, Hume's central problem is by no means hard to grasp, particularly if the Descartes-Newton scheme be recalled. Granted that *separation* of individuals, whether of men, of material bodies or of thought and extension, constitutes the fundamental fact in the universe; granted, too, that knowledge flows into consciousness through the senses, then what value can be attached legitimately to human experience? Hume, as one must always remember, possessed the wit not to rest satisfied with the dogmas that appeased his forefathers after the intellect. He wanted to know what precise inferences could be extracted from their cherished opinions, and he suspected that their satisfaction had not been won fairly. Accordingly, he showed, and the proof holds good beyond peradventure, that, on this traditional basis, human knowledge can be viewed only as a huge delusion. Objects, self and deity; matter, mind and cause; science and philosophy engulf themselves. Another alternative is impracticable, if the presuppositions, common to the mathematico-physical sciences, to the Cartesian metaphysics and to the British psychology, be admitted. It was no part of Hume's task to examine this foundation. He accepted it without change as it came to him and proved, in the most thoroughgoing fashion, that universal nescience was its sole logical end. Dualism, self-contained bodies, sensationalism, 'an agent acting constantly according to certain laws'—in short, the entire paraphernalia held conjointly by the science and philosophy of the seventeenth and eighteenth centuries, he hoisted with its own petard and blew to shivers irretrievably. For, admit his premises and the conclusion follows resistlessly. Now, the view of the universe prevalent from Descartes to Paley, from Galileo to Laplace, depended on Hume's premises and upon nothing else! So ended the first lesson, like its kind, not to be taken to heart for many a long day.

If the real implications of Hume's argument remained hidden from science, thanks to the continued predominance of the 'Newtonian philosophy,' and from the men who spoke Hume's tongue, thanks to contemporary political and theological causes, the same cannot be said of Kant. His philosophy took Europe by storm and has continued to influence scientific men perhaps more than any other body of philo-

sophical thought. His contribution to our present subject of inquiry consisted of two parts: (*a*) the distinction between *Verstand* and *Vernunft,* (*b*) the conclusions gained in the last division of his masterpiece, the 'Critique of Pure Reason.' The former was destined to exercise decisive effect on the relation between science and philosophy; the latter, as I understand the 'Dialectic,' met much the same fate as Hume's destructive analysis—it was misinterpreted or overlooked. We may therefore take it first, and very briefly. In the third part of the 'Critique of Pure Reason,' entitled 'Dialectic,' because it deals with subjects capable of dialectical treatment, Kant shows that the metaphysic of his predecessors must be adjudged a complete failure. Mathematics and physics exist, for they have objects; but metaphysics has no existence, its objects are unthinkable, humanly speaking. Take the soul (or self) as a *self-contained* thing, occupying a place among the other *self-contained* elements of human life; interpret the universe as a *self-contained* object, one among other objects of experience; conceive God as a *self-contained* 'agent acting constantly according to certain laws,' and residing far out in the depths of space; in a word, let your fundamental conceptions be those of the Descartes-Newton type; then, when you come to analyze them, you will find of a surety that no such soul or universe or God can possibly enter into human experience. This Kant proves, and so cuts the throat of the metaphysic which ruled science and philosophy from the Reformation till his day. On the whole, philosophers have not yet fathomed his meaning, while scientific men have been quick to seize his point, that metaphysic does not exist, forgetting completely that his work was preliminary to the necessary question: What, then, *are* soul, the universe and God? To declare, with a certain quasi-scientific school, that these are mere ideas, helps us not a whit. For the declaration, as they do not see, destroys the validity of science also. Thus, on a broad view, we have still to reckon with this aspect of Kant's thought.

The distinction between *Verstand* (understanding) and *Vernunft* (reason)—the English words fail to translate, unfortunately—stands in very different case, having been productive of momentous consequences. Kant's early scientific researches led him to see that a dynamical account of the material universe ought to be substituted for the static conception of Newton. Indeed, he hit upon the idea of preorganic evolution; but, as thermodynamics lay in the future, experimental evidence lacked, and he was switched on to another line by Hume. According to Hume, knowledge is phenomenal, and phenomenal only. It consists of what apppears to be; can have no commerce with what is. By analysis, the most complex ideas can be proved to possess a phenomenal basis. The faculty of analysis, which deals thus with phenomena, Kant called *Verstand.* But he insisted that Hume's

assumption, that knowledge comes from the senses, did not suffice to explain experience. Man's mind is endowed with certain forms or principles of synthesis, by means of which the sense-material is organized into knowledge. *Vernunft* is the faculty whereby such principles may be apprehended. It implies a higher range and a deeper insight than *Verstand*. This superior faculty, in combination with an amplified reading of Herder's theory of historical evolution, was to be responsible for much, as we shall see in the sequel.

Herder, a younger contemporary of Kant, turned away from the mathematico-physical sciences, to which nearly all great intellects had been attracted for two centuries, and entered enthusiastically upon the study of the history of culture, of culture in the spacious sense of civilization. Even in this line of research, he can not be called an exact student. But his was a vitalizing personality, and so, his limitations notwithstanding, he originated the evolutionary and organic idea which may be termed appropriately *the* nineteenth century standpoint. He took particular delight in poetry, religion, language and the like. As early as 1767, he enunciated the conception which was to create historical science. "There is the same law of change in all mankind and in every individual, nation and tribe. From the bad to the good, from the good to the better and best, from the best to the less good, from the less good to the bad—this is the circle of all things. So it is with art and science; they grow, blossom, ripen and decay. So it is with language also." In the realm of the human spirit, all things work together; "history leads us into the council of fate, teaches us the eternal laws of human nature and assigns us our own place in that great organism in which reason and goodness . . . must create order."

At this point we strike the psychological moment when the conditions that led to the conflict between science and philosophy were assembling. Evidently, the center of gravity of philosophical inquiry would be shifted from the old mathematico-physical parallelism, if a professed philosopher were to appear equipped with the insight and speculative daring requisite to unite Kant's conception of *Vernunft* with Herder's fruitful suggestion, that history is a vast organism 'in which *reason* must create order.' This epoch-making thinker did arise, in the person of Hegel. We can not stay to outline the Hegelian system, but must rest content to state its germinal idea. Following upon Herder's pregnant thought, Hegel conceived of the universe as a single unity, inspired and controlled by a principle of reason, a principle in and through and for which everything has being. Obviously, if the human mind can grasp such a principle, Kant's faculty of *Vernunft* is the one power endowed with the necessary ability. As obviously, on these conditions, if a thinker can pick out, as it were, the rational

forms under which this principle manifests itself, he will have mastered the mystery of all things. From the year 1818, the date of Hegel's election to the chair of philosophy in the University of Berlin, till the break-up of his school, about 1850, his thought dominated the intellect of Germany to a degree unparalleled, and from 1865 till the present time, it has wielded power in the British and, to a lesser extent, in the American universities. The reason for this is patent. No other thinker entertained *modern* views. In the English-speaking countries particularly, men faced the past, not the future. Hegel, on the contrary, whatever may be said in his despite, had carried the dynamic, organic and evolutionary explanation into every corner of the humanistic realm. Nevertheless, he and his disciples must bear the chief responsibility for the estrangement between science and philosophy throughout forty years (1850-90) of the nineteenth century. Why?

In the first place, this, the most influential system of modern philosophy, had been completed to all intents and purposes by the year 1816. And, unfortunately, this statement implies another. In 1816, modern science was as yet unborn. Of course, one does not forget the work of Haller, at Göttingen; of Cuvier and Bichat; of Treviranus, who was the first to use the term 'biology,' in 1802; and, above all, one calls to mind Charles Bell's capital discovery, in 1811. Still, all these died in the faith, they having received not the promises. In France, mathematical science maintained its glorious history, thanks partly to the favor of Napoleon. In Germany, the rule of the modern scientific spirit dates from 1826, with the foundation of Liebig's laboratory at Giessen. In Britain, all the great advances, Bell's excepted, fall within the domain of astronomy, physics and the older chemistry. Yet, despite this meager knowledge, as we deem it now, of the intricacies of nature, a thinker dared to present an absolute philosophy—a key to all the mysteries.

In the second place, the interpretation of Hegel's system by his followers, if not its elaboration by himself, had become increasingly formal, perhaps abstract, just at the moment when science was making some of its most astonishing discoveries. Small wonder, then, that investigators of nature, successful beyond all precedent, turned in contempt from a philosophy which seemed to them, rightly or wrongly, a species of revived scholasticism. Moreover, the bitter attacks on Hegel emanating from workers on the philosophical side, like Herbart and his pupils, who appeared to be, and possibly were, sympathetic with scientific methods, served to deepen this impression. By 1865, when the cry, 'Back to Kant!' had taken effective possession of many and was emphasizing the importance, for science, of a certain interpretation of Kant's thought, this antagonism crystallized finally.

Lastly, Hegel's 'Naturphilosophie,' containing his account of those

phenomena of nature to which he attempts to apply his principles, was the weakest spot in his system. As the sciences progressed, this became more and more evident, and it would have been asking too much of human nature to have required the enemy to forego this grand opportunity for telling assault. No doubt, these attacks went too far, as the formative influence of the 'Philosophy of Nature' upon men like Oken, Oersted, K. E. von Baer, Johannes Müller and Schönlein proves overwhelmingly. Nevertheless, the fact remains that the insights of 'Naturphilosophie' were not restored to scientific citizenship till late in the century, and its unchastened speculations alone attracted general attention in pre-Darwinian times. In this field, the decisive one for science, be it remembered, the vaunted higher and special knowledge of philosophy was adjudged guilty of ludicrous error, of gross carelessness, of otiose imaginings.

While the newer science thus scouted the new philosophy, was it without sin? In answering this question, we come upon what I have called one of the greatest paradoxes of history. Just after the nineteenth century had passed its zenith, a group of writers, penetrated by the dynamical and biological tendencies of contemporary science, thought that the times were ripe for an accordant theory of the universe. The discoveries of Wöhler, who produced an organic substance by the synthesis of inorganic materials; the startling advances of biology, especially in the physiological line; and the speculations of such thinkers as Schopenhauer and Feuerbach, appeared to furnish a ground for *scientific* explanation of certain factors in experience which had defied interpretation hitherto. Thus, despite its contempt for the regnant philosophy, science, stimulated by its own problems, produced a philosophical theory. Opponents of this movement, like opponents in all ages, thought to get rid of an irritating novelty by means of a nickname. Accordingly, we hear of the *monism* of Moleschott, Büchner, Carl Vogt and Haeckel. By applying this title, critics intended to indicate that these thinkers suppressed the great differences of experience—the difference between matter and mind or between the organic and the inorganic—and saddled one term, in this case, matter or the inorganic, with the entire responsibility of a solution. Now, it is true that this school alleged matter to be the cause of mind, that they said, 'brain secretes thought as the liver secretes bile,' and did many other things equally foolish or objectionable. At the same time, their critics stood too near them and a clearly defined focus was unobtainable. The real fact was—and here the paradox emerges—that Büchner and the rest set up, not a monism, but a dogmatism. Despite the circumstance that the progress of science, to say nothing of Hume and Kant, had demonstrated beyond doubt the insufficiency and fallacy of the dualistic, static and analytic theory of

the universe, they *accepted this as a presupposition.* To begin with, matter and mind were not one, but two; they were different, that is. Given this difference, then, how explain them? By showing that, in the time series, mind came second, and was therefore caused by matter. The laughable paradox is that men steeped in the biological view, which utterly overturns this mechanical externality, adopted the latter as *the* means adequate to account for the former! Of course, a man may do this, if he please, but at his peril. For, Hume and Kant and the biological sciences have combined to show that, even before it could be stated, this doctrine had become, not merely untenable, but positively unthinkable. It was now the philosophers' turn to blaspheme their brethren of science. If the errors of 'Naturphilosophie' had handed speculative thought over to the tender mercies of exact science, the ludicrous obtuseness of the so-called materialists respecting what was possible in philosophy brought the thinkers their due revenge. Thus the dispute became interminable and the Jew had no dealings with the Samaritan. For science, philosophy appeared so much vague or formal speculation; for philosophy, science, in so far as it tried to explain the world, seemed nothing but a blind blundering among exploded errors peculiar to Locke and the French encyclopedists. Despite Lotze's effort at mediation, too complacent towards both parties to command the respect of either, this was the substantial situation from 1850 till 1885. And, when we hear to-day of the opposition between science and philosophy, our ears are really ringing with echoes from the period of the great paradox. The later developments of physics, chemistry, biology and psychology have brought scientific men to a point where they can see that the mere adoption of the 'Newtonian philosophy,' minus the 'agent acting constantly according to certain laws,' is a far too simple solution of the obscure problems on hand. Seductive it may be, it fails notoriously to fill the bill. Similarly, philosophers begin to understand that Hegelianism must go as a system, even though they feel that they must retain Hegel's one contribution to progress—the principle that experience can be explained, if at all, only by reference to itself. Also they evince symptoms of perceiving that the watchword, 'Back to Kant!' valuable enough in 1860, must be replaced by the new rallying cry, 'Forward from Kant.' The critical philosophy cleared a site upon which it is possible and proper for science and speculation to cooperate in building now.

Science and philosophy may easily return to the old footing, then, if they will but have a mind to rid themselves of the peculiar dogmas that have afflicted each during the last century. This implies mutual self-sacrifice, but sacrifice of the unimportant, very likely of the harmful. There is no good ground for the belief that with the circle

of the positive sciences knowledge ends; for the naïve supposition that an object can exist without a subject; for the marvelous delusion that observation and experiment are capable of revealing things new and old without the aid of mental synthesis or of psychological volition; for the charming inconsequence that we perceive phenomena and are therefore ignorant of reality. But equally, no basis can be found for the idea that philosophy has means of access to some special knowledge denied science; that one can afford to neglect science in favor of rational forms; that the conclusions of physics, chemistry and biology are subject to revision at a higher tribunal; or that the work of the sciences is a monstrous delusion. On the contrary, there is every reason for insisting that science and philosophy are interwined inextricably—much more inextricably now than they could have been in Newton's time. Both work upon the same *closed* universe. This is the important fact, even if science inquires, What is it? philosophy, What does it mean? Nay, both questions are unanswerable, and so the two disciplines alike end in approximation and hypothesis. As Romanes has put it, "The 'Origin of Species' first clearly revealed to naturalists as a class that it was the duty of their science to take as its motto what is really the motto of natural science in general, 'Felix qui potuit rerum cognoscere causas,' not facts, then, or phenomena, but causes or principles are the ultimate objects of scientific quest." They are the objects of philosophical quest also, as Romanes shows elsewhere. In a word, to become conscious of its own fundamental principles, science must transform itself into a kind of philosophy, while to become acquainted with its own illustrative material, philosophy must transform itself into a kind of science. This way lie harmony and progress. We expect the twentieth century to furnish forth the imperative eirenicon. It can not come too soon.

A STUDY OF BRITISH GENIUS.

By HAVELOCK ELLIS.

IX.—PERSONAL CHARACTERISTICS.

BEFORE summarizing the results of this study and noting a few of the conclusions to which it seems to point, there are still some aspects of British men of genius that the 'Dictionary' serves to make visible. And as these aspects enable us at once both to complete our picture and to confirm some of the impressions we have already obtained, we cannot afford to pass them by. They concern more especially personal appearance and emotional disposition.

As regards stature we have some information in 281 cases; in 218 cases the information is indefinite, in the remaining 63 cases definite. Of the first and largest group, 91 are said to be tall, 53 of average or medium height, while 74 are short. In the smaller group, composed entirely of males, 4 are 5 feet and under;* 5 are from 5 feet 1 to 5 feet 4; 14 are from 5 feet 5 to 5 feet 8; 26 are from 5 feet 9 to 6 feet; 14 are over 6 feet. The height of the average Englishman at the present day is 5 feet 8. It may be added that among the general population of the British Islands 68 per cent. are between 5 feet 4 inches and 5 feet 9 inches in height. But the average height of men of the well-to-do classes, to which our subjects mainly belong, is somewhat above this. If we say that it is 5 feet 9, we shall probably be near the mark. This is confirmed by Galton, who found that the average height of the fathers of his men of science was 5 feet 9¼. But if this is so, it would appear that it is the tendency of our men of genius not only to vary widely, but to be tall more frequently than short.† The center of the group is really occupied by the individuals who are 5 feet 10, since 29 are below this height and 27 above it.

It must, of course, be recognized that various fallacies would be involved were we to take our data as strictly corresponding to the real facts. The exceptional people are more likely to be mentioned, and the medium-sized to be passed over, while there is always a tendency to describe a person as short or tall, rather than as of average size. It

* Pope, 4 feet 6, is excluded, as his excessively low stature was the result of deformity.

† I may remark that among the ordinary population there is some reason to suppose that superior intellectual capacity tends to be associated with superior stature; Porter found such an association among school children at St. Louis and Christopher at Chicago.

may be noted, however, that the group for which we have definite figures harmonizes fairly with the group for which we have no definite figures, and that both alike show that the number of medium-sized persons is vastly below what we ought to expect. Moreover, the group with definitely ascertained heights shows very wide range of variation. When we note that among some 850 men there are 14 who are definitely known to have been over 6 feet in height, and many others who are known to have been 'gigantic' or 'colossal,' we may be fairly certain that more definite knowledge would only show more clearly that the relations that rule here are not exactly the same as those that rule among the general population, and that men of intellectual ability show in this respect a greater tendency to variation than is observed among the general population.*

It is interesting to note that although among the general population the well-to-do classes are decidedly taller than the lower social classes, no such tendency is clearly marked in our groups. Confining ourselves to the group with definitely known height, we find that none belong to our 'good family' class, while two belong to our lowest social class, springing from unskilled workers. The extremely small persons belong to the middle or lower middle social classes. This seems to indicate that height is here not a mere social phenomenon, but a real expression of the organic vitality and nervous make of the man.

It would be of much interest if we could speak definitely concerning the most important of all anthropological criteria, the cephalic index or length-breadth index of the head. The 'Dictionary' here, however, is of no assistance. We are told, indeed, of Faraday (the writer of the article being Tyndall) that he had an abnormally long head, so that his hats had to be specially made for him, and we are told of Tyndall himself (the writer here being his widow) that in this respect Tyndall resembled Faraday. This scrap of evidence, so far as it goes, would confirm the proverbial belief in favor of the intelligence of long-headed persons. It is, however, believed by many, who can bring forward good evidence on their side, that intellectual ability goes with broad-headedness. It may well be that in this matter, as in that of stature, the range of variation is great, and that both extremes tend to prevail to an undue extent. This has been found to be the case in another abnormal group—that of criminals.

If we turn to a further anthropological character, pigmentation, or the color of the hair and eyes, we are able to bring forward a much larger body of evidence, and it is not difficult to supplement the data

* This conclusion harmonizes with an inquiry into this matter, and into its significance—not, however, confined to persons of British race—which I published elsewhere a few years ago ('Genius and Stature,' 'Nineteenth Century,' July, 1897).

furnished by the 'Dictionary' by the help of portraits, more especially those in the National Portrait Gallery. I have information on this point concerning 334 of the eminent persons on our list. In classifying by pigmentation I have relied in the first place on the eye-color, but have allowed hair-color a certain influence in modifying the class in those cases in which there was marked divergence between the two in lightness or darkness. I have sorted the eminent persons into three classes, according as their eyes were unpigmented (blue), highly pigmented (brown), or occupying an intermediate position (combinations of blue with yellow, orange or brown). This intermediate class has necessarily been large, and I have comprised within it three subdivisions: a fair medium, a dark medium, and, between these two, a doubtful medium. Then the question arose as to how the results thus obtained might be conveniently formulated, so as to enable us to compare the different groups of eminent persons. I finally decided to proceed with each of these groups as follows: The doubtful medium persons in each of these classes were divided equally between the fair medium and the dark medium; then two-thirds of the fair-medium persons were added to the fair class, the remaining third to the dark class, and, likewise, two-thirds of the dark medium were added to the dark class, the remaining third to the fair class; the five classes were thus reduced to two, and, on multiplying the fair by 100 and dividing by the dark, we obtain what may be called an index of pigmentation. This method of notation is really simple, and is quite sufficiently accurate for the nature of the data dealt with; it will be seen that by its use an index of 100 means that fair and dark people are equally numerous in a group, while indices over 100 mean an excess of fair persons, and indices under 100 an excess of dark persons. I have been able to obtain the index of pigmentation in the cases of ten groups, the remaining groups being too small to permit of assured results. I present them, with their index of pigmentation, in the order of decreasing fairness: Men of science, 150; Artists, 108; Lawyers, 100; Sailors, 100; Soldiers, 83; Statesmen, 83; Poets, 78; Men of letters, 67; Divines, 43; Actors, 20.

It will be seen that the range is considerable; but I believe we may have considerable confidence in the results, and the more so since they are not altogether unexpected, for (although I do not wish to assume that these phenomena are entirely explicable by race) it is certainly true that men of science and artists tend largely to come from fair districts of the country, divines and actors from dark districts. The fact that allied classes tend to fall together—soldiers and sailors, poets and men of letters—also gives confidence in the reality of the relationship thus brought out. It may be noted, as a fact probably not without significance, that the more active and unemotional classes tend

to be fair, while the more reflective and emotional classes tend to be dark.*

There is another physical characteristic to which the national biographers frequently allude, though I do not propose to attempt to give it any numerical values, and that is personal beauty or the absence of it. A very large proportion of persons are referred to as notably handsome, comely, imposing; a very considerable, but smaller, proportion are spoken of as showing some disproportion or asymmetry of feature, body or limbs, as notably peculiar or even ludicrous in appearance. A not uncommon type is that of the stunted giant, with massive head and robust body, but very short legs.

There is one feature, however, which is noted as striking and beautiful in a very large number of cases, even in persons who are otherwise wholly without physical attractions. That is the eyes. It is nearly always found that descriptions of the personal appearance of men of genius, however widely they may differ in other respects, agree in finding an unusual brilliancy of the eyes. Thus the eyes of Burns were said by one observer to be like 'coals of living fire,' and Scott writes that they 'literally glowed'; while of Chatterton's eyes it was said that there was 'fire rolling at the bottom of them.' It is significant that both of these instances, chosen almost at random, were poets. While, however, the phenomenon seems to be noted more frequently and with more emphasis in poets, it is found among men of genius of all classes. One can only suppose it to be connected with an unusual degree of activity of the cerebral circulation.

In regard to the mental and emotional disposition of British persons of genius, the national biographers enable us to trace the prevalence of one or two tendencies. One of these is shyness, bashfulness or timidity. This is noted in thirty-four cases, while thirty-two others are described as very sensitive, nervous or emotional, and, although this is not equivalent to a large percentage, it must of course be remembered that the real number of such cases is certainly very much larger, and also that the characteristic is in many cases extremely well marked. Some had to abandon the profession they had chosen on account of their nervous shyness at appearing in public; others were too bashful to declare their love to the women they were attracted to; Sir Thomas

*I may remark concerning this index of pigmentation that, while it yields results which are strictly comparable among themselves in the hands of a single observer, proceeding in a uniform manner, it is doubtful whether two observers would carry it out in a strictly identical manner. Beddoe's index of nigrescence, founded on hair-color and applied directly to living subjects, is a convenient formula for indicating the degree of pigmentation. But in my observations, largely made on portraits (in which the hair was often whitened by age, absent, concealed beneath a wig, or obscured by the darkening of the paint), it was necessary to accept eye-color as the primary basis of classification.

Browne, one of the greatest masters of English prose, was so modest that he was always blushing causelessly; Hooker, one of the chief luminaries of the English Church, could never look any one in the face; Dryden, the recognized prince of the literary men of his time, was, said Congreve, the most easily put out of countenance of any man he had ever met. It is not difficult to see why the timid temperament —which is very far from involving lack of courage*—should be especially associated with intellectual aptitudes. It causes a distaste for social contact and so favors those forms of activity which may be exerted in solitude, these latter, again, reacting to produce increased awkwardness in social relations. Moreover, the mental state of timidity, which may be regarded as a mild form of *folie du doute,* a perpetual self-questioning and uncertainty, however unpleasant it may be from the social point of view, is by no means an unsatisfactory attitude in the face of intellectual problems, for it involves that unceasing self-criticism which is an essential element of all good intellectual work, and has marked more or less clearly the greatest men of scientific genius. Fundamentally, no doubt, timidity is a minor congenital defect of the nervous mechanism, fairly comparable to stammering. It may be noted that the opposite characteristic of over self-confidence, with more or less tendency to arrogance and insolence, is also noted, but with much less frequency, and usually in men whose eminence is not due to purely intellectual qualities. In some cases, it would seem, the two opposite tendencies are combined, the timid man seeking refuge from his own timidity in the assumption of arrogance.

In a certain number of cases information is given as to the general emotional disposition, whether to melancholy and depression, or of a gay, cheerful and genial character. In sixty-two cases the disposition is noted as melancholy, in twenty-nine as cheerful or jovial; in eight cases both dispositions are noted as occurring, in varying association, in the same person. This marked tendency to melancholy among persons of intellectual aptitude is no new observation, but was indeed one of the very earliest points noted concerning men of genius. It was remarked by Aristotle, and Reveillé-Parise, one of the earliest and still one of the most sagacious of the modern writers on genius, devoted a chapter to the point. It is not altogether difficult to account for this phenomenon. Melancholy children, as Marro found, are in large proportion the offspring of elderly fathers, as we have also found our persons of intellectual eminence to be. A tendency to melancholy, again, even though it may always fall short of insane melancholia, is allied to those neurotic and abnormal conditions which we have

* "None are so bold as the timid when they are fairly roused," wrote Mrs. Browning in her 'Letters.' The same point has been brought out by Dugas in his essay on timidity.

found to be not infrequent. Moreover, it certainly has a stimulating influence on intellectual work. The more normal man of cheerful disposition instinctively seeks the consolations of society. The melancholy man, like the shy man, is ill-adapted to society, and more naturally seeks his consolations in a non-social field, such as that of the intellect, often plunging more deeply into intellectual work the more profound his melancholy becomes. Wagner said that his best work was done at times of melancholy, and among the eminent men on our list several writers are mentioned who turned to authorship as a relief to personal depression. It may also be said that not only is melancholy a favorable condition for intellectual work, but that the sedentary and nerve-exhausting nature of nearly all forms of intellectual work in turn reacts to emphasize or produce moods of depression.

There is another cause which serves to explain or to accentuate the tendency of men of genius to melancholy. I refer to the attitude of the world towards them. Every original worker in intellectual fields, every man who makes some new thing, is certain to arouse hostility where he does not meet with indifference. He sets out in his chosen path, ignorant of men, but moved by high ideals, content to work in laborious solitude and to wait, and when at last he turns to his fellows, saying, 'See what I have done for you!' he finds that he has to meet only the sneering prejudices of the few who might have comprehended, and the absolute indifference of the many who are too absorbed in the daily struggle for bread to comprehend any intellectual achievement. The wise worker knows this and arms himself with contempt, as a protection alike against the few and the many;* but it has to be remembered that the prevailing temperament of men of genius is one of great nervous sensitiveness and irritability—so that, as Reveillé-Parise puts it, they are apt to 'roar at a pin-prick'—and even when they are well aware what the opinion of the world is worth, they still cannot help being profoundly affected by that opinion. Hence a fruitful source of melancholy.

The attitude of the world towards the man of original intellect is, however, by no means one merely of disdain or indifference. It constantly tends to become more aggressive. It is practically impossible to estimate the amount of persecution to which this group of preeminent British persons has been subjected, for it has shown itself in innumerable forms, and varies between a mere passive refusal to

* Thus of one of the great men of science on our list, Stephen Hales, it was said that he could look "even upon those who did him unkind offices without any emotion of particular indignation, not from want of discernment or sensibility; but he used to consider them only like those experiments which, upon trial, he found could never be applied to any useful purpose, and which he therefore calmly and dispassionately laid aside."

have anything whatever to do with them or their work and the active infliction of physical torture and death. There is, however, at least one form of persecution, very definite in character, which it is easy to estimate, since the national biographers have probably in few cases passed it over. I refer to imprisonment. I find that over 14 per cent. of these 902 eminent persons were imprisoned, once or oftener, for periods of varying length, while many others only escaped imprisonment by voluntary exile. It is true that the causes of imprisonment were various, but even imprisonment for debt may usually be taken to indicate an anomalous lack of adjustment to the social environment. The man of genius is an abnormal being, thus arousing the instinctive hostility of society, which by every means seeks to put him out of the way.

It will be seen that the various personal traits noted in this section, while completing our picture of British persons of genius, may be linked on at various points to other traits we have previously noted. It only remains to gather together the various threads we have traced and to ascertain how far they may be harmoniously woven into a complete whole.

FREDERIC MYERS'S SERVICE TO PSYCHOLOGY.*

By PROFESSOR WILLIAM JAMES,
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ON this memorial occasion it is from English hearts and tongues belonging, as I never had the privilege of belonging, to the immediate environment of our lamented President, that discourse of him as a man and as a friend must come. It is for those who participated in the endless drudgery of his labors for our Society to tell of the high powers he showed there; and it is for those who have something of his burning interest in the problem of our human destiny to estimate his success in throwing a little more light into its dark recesses. To me it has been deemed best to assign a colder task. Frederic Myers was a psychologist who worked upon lines hardly admitted by the more academic branch of the profession to be legitimate; and as for some years I bore the title of 'Professor of Psychology,' the suggestion has been made (and by me gladly welcomed) that I should spend my portion of this hour in defining the exact place and rank which we must accord to him as a cultivator and promoter of the science of the mind.

Brought up entirely upon literature and history, and interested at first in poetry and religion chiefly; never by nature a philosopher in the technical sense of a man forced to pursue consistency among concepts for the mere love of the logical occupation; not crammed with science at college, or trained to scientific method by any passage through a laboratory; Myers had as it were to re-create his personality before he became the wary critic of evidence, the skilful handler of hypothesis, the learned neurologist and omnivorous reader of biological and cosmological matter, with whom in later years we were acquainted. The transformation came about because he needed to be all these things in order to work successfully at the problem that lay near his heart; and the ardor of his will and the richness of his intellect are proved by the success with which he underwent so unusual a transformation.

The problem, as you know, was that of seeking evidence for human immortality. His contributions to psychology were incidental to that research, and would probably never have been made had he not entered on it. But they have a value for science entirely inde-

* From the 'Proceedings of the Society for Psychical Research.'

pendent of the light they shed upon that problem; and it is quite apart from it that I shall venture to consider them.

If we look at the history of mental science we are immediately struck by diverse tendencies among its several cultivators, the consequence being a certain opposition of schools and some repugnance among their disciples. Apart from the great contrasts between minds that are teleological or biological and minds that are mechanical, between the animists and the associationists in psychology, there is the entirely different contrast between what I will call the classic-academic and the romantic type of imagination. The former has a fondness for clean pure lines and noble simplicity in its constructions. It explains things by as few principles as possible and is intolerant of either nondescript facts or clumsy formulas. The facts must lie in a neat assemblage, and the psychologist must be enabled to cover them and 'tuck them in' as safely under his system as a mother tucks her babe in under the down coverlet on a winter night. Until quite recently all psychology, whether animistic or associationistic, was written on classic-academic lines. The consequence was that the human mind, as it is figured in this literature, was largely an abstraction. Its normal adult traits were recognized. A sort of sunlit terrace was exhibited on which it took its exercise. But where that terrace stopped, the mind stopped; and there was nothing farther left to tell of in this kind of philosophy but the brain and the other physical facts of nature on the one hand, and the absolute metaphysical ground of the universe on the other.

But of late years the terrace has been overrun by romantic improvers, and to pass to their work is like going from classic to Gothic architecture, where few outlines are pure and where uncouth forms lurk in the shadows. A mass of mental phenomena are now seen in the shrubbery beyond the parapet. Fantastic, ignoble, hardly human, or frankly non-human are some of these new candidates for psychological description. The menagerie and the madhouse, the nursery, the prison, and the hospital, have been made to deliver up their material. The world of mind is shown as something infinitely more complex than was suspected; and whatever beauties it may still possess, it has lost at any rate the beauty of academic neatness.

But despite the triumph of romanticism, psychologists as a rule have still some lingering prejudice in favor of the nobler simplicities. Moreover there are social prejudices which scientific men themselves obey. The word 'hypnotism' has been trailed about in the newspapers so that even we ourselves rather wince at it, and avoid occasions of its use. 'Mesmerism,' 'clairvoyance,' 'medium'—*horrescimus referentes!*—and with all these things, infected by their previous mystery-mongering discoverers, even our best friends had rather avoid complicity. For

instance, I invite eight of my scientific colleagues severally to come to my house at their own time, and sit with a medium for whom the evidence already published in our 'Proceedings' had been most noteworthy. Although it means at worst the waste of the hour for each, five of them decline the adventure. I then beg the 'Commission' connected with the chair of a certain learned psychologist in a neighboring university to examine the same medium, whom Mr. Hodgson and I offer at our own expense to send and leave with them. They also have to be excused from any such entanglement. I advise another psychological friend to look into this medium's case, but he replies that it is useless, for if he should get such results as I report, he would (being suggestible) simply believe himself hallucinated. When I propose as a remedy that he should remain in the background and take notes, whilst his wife has the sitting, he explains that he can never consent to his wife's presence at such performances. This friend of mine writes *ex cathedra* on the subject of psychical research, declaring (I need hardly add) that there is nothing in it; the chair of the psychologist with the Commission was founded by a spiritist, partly with a view to investigate mediums; and one of the five colleagues who declined my invitation is widely quoted as an effective critic of our evidence. So runs the world away! I should not indulge in the personality and triviality of such anecdotes, were it not that they paint the temper of our time, a temper which, thanks to Frederic Myers more than to any one, will certainly be impossible after this generation. Myers was, I think, decidedly exclusive and intolerant by nature. But his keenness for truth carried him into regions where either intellectual or social squeamishness would have been fatal, so he 'mortified' his *amour propre,* unclubbed himself completely, and became a model of patience, tact, and humility wherever investigation required it. Both his example and his body of doctrine will make this temper the only one henceforward scientifically respectable.

If you ask me how his doctrine has this effect, I answer: *By coordinating!* For Myers's great principle of research was that in order to understand any one species of fact we ought to have all the species of the same general class of fact before us. So he took a lot of scattered phenomena, some of them recognized as reputable, others outlawed from science, or treated as isolated curiosities; he made series of them, filled in the transitions by delicate hypotheses or analogies, and bound them together in a system by his bold inclusive conception of the Subliminal Self, so that no one can now touch one part of the fabric without finding the rest entangled with it. Such vague terms of apperception as psychologists have hitherto been satisfied with using for most of these phenomena, as 'fraud,' 'rot,' 'rubbish,' will no more be possible hereafter than 'dirt' is possible

as a head of classification in chemistry, or 'vermin,' in zoology. Whatever they are, they are things with a right to definite description and to careful observation.

I cannot but account this as a great service rendered to psychology. I expect that Myers will ere long distinctly figure in mental science as the radical leader in what I have called the romantic movement. Through him for the first time, psychologists are in possession of their full material, and mental phenomena are set down in an adequate inventory. To bring unlike things thus together by forming series of which the intermediary terms connect the extremes, is a procedure much in use by scientific men. It is a first step made towards securing their interest in the romantic facts, that Myers should have shown how easily this familiar method can be applied to their study.

Myers's conception of the extensiveness of the Subliminal Self quite overturns the classic notion of what the human mind consists in. The supraliminal region, as Myers calls it, the classic-academic consciousness, which was once alone considered either by associationists or animists, figures in his theory as only a small segment of the psychic spectrum. It is a special phase of mentality, teleologically evolved for adaptation to our natural environment, and forms only what he calls a 'privileged case' of personality. The outlying Subliminal, according to him, represents more fully our central and abiding being.

I think the words subliminal and supraliminal unfortunate, but they were probably unavoidable. I think, too, that Myers's belief in the ubiquity and great extent of the Subliminal will demand a far larger number of facts than sufficed to persuade him, before the next generation of psychologists shall become persuaded. He regards the Subliminal as the enveloping mother-consciousness in each of us, from which the consciousness we wot of is precipitated like a crystal. But whether this view get confirmed or get overthrown by future inquiry, the definite way in which Myers has thrown it down is a new and specific challenge to inquiry. For half a century now, psychologists have fully admitted the existence of a subliminal mental region, under the name either of unconscious cerebration or of the involuntary life; but they have never definitely taken up the question of the extent of this region, never sought explicitly to map it out. Myers definitely attacks this problem, which, after him, it will be impossible to ignore.

What is the precise constitution of the Subliminal—such is the problem which deserves to figure in our science hereafter as the *problem of Myers;* and willy-nilly, inquiry must follow on the path which it has opened up. But Myers has not only propounded the problem definitely, he has also invented definite methods for its solution. Post-hypnotic suggestion, crystal-gazing, automatic writing and trance-speech, the willing-game, etc., are now, thanks to him, instruments of

research, reagents like litmus paper or the galvanometer, for revealing what would otherwise be hidden. These are so many ways of putting the Subliminal on tap. Of course without the simultaneous work on hypnotism and hysteria independently begun by others, he could not have pushed his own work so far. But he is so far the only generalizer of the problem and the only user of all the methods; and even though his theory of the extent of the Subliminal should have to be subverted in the end, its formulation will, I am sure, figure always as a rather momentous event in the history of our science.

Any psychologist who should wish to read Myers out of the profession—and there are probably still some who would be glad to do so to-day—is committed to a definite alternative. Either he must say that we knew all about the subliminal region before Myers took it up, or he must say that it is certain that states of super-normal cognition form no part of its content. The first contention would be too absurd. The second one remains more plausible. There are many first-hand investigators into the Subliminal who, not having themselves met with anything super-normal, would probably not hesitate to call all the reports of it erroneous, and who would limit the Subliminal to dissolutive phenomena of consciousness exclusively, to lapsed memories, subconscious sensations, impulses and *phobias,* and the like. Messrs. Janet and Binet, for aught I know, may hold some such position as this. Against it Myers's thesis would stand sharply out. Of the Subliminal, he would say, we can give no ultra-simple account: there are discrete regions in it, levels separated by critical points of transition, and no one formula holds true of them all. And any conscientious psychologist ought, it seems to me, to see that, since these multiple modifications of personality are only beginning to be reported and observed with care, it is obvious that a dogmatically negative treatment of them must be premature, and that the problem of Myers still awaits us as the problem of far the deepest moment for our actual psychology, whether his own tentative solutions of certain parts of it be correct or not.

Meanwhile, descending to detail, one cannot help admiring the great originality with which Myers wove such an extraordinarily detached and discontinuous series of phenomena together. Unconscious cerebration, dreams, hypnotism, hysteria, inspirations of genius, the willing-game, planchette, crystal-gazing, hallucinatory voices, apparitions of the dying, medium-trances, demoniacal possession, clairvoyance, thought-transference—even ghosts and other facts more doubtful—these things form a chaos at first sight most discouraging. No wonder that scientists can think of no other principle of unity among them than their common appeal to men's perverse propensity to superstition.

Yet Myers has actually made a system of them, stringing them continuously upon a perfectly legitimate objective hypothesis, verified in some cases and extended to others by analogy. Taking the name automatism from the phenomenon of automatic writing—I am not sure that he may not himself have been the first so to baptize this latter phenomenon—he made one great simplification at a stroke by treating hallucinations and active impulses under a common head, as *sensory* and *motor automatisms*. Automatism he then conceived broadly as a message of any kind from the Subliminal to the Supraliminal. And he went a step farther in his hypothetic interpretation, when he insisted on 'symbolism' as one of the ways in which one stratum of our personality will often interpret the influences of another. Obsessive thoughts and delusions, as well as voices, visions, and impulses, thus fall subject to one mode of treatment. To explain them, we must explore the Subliminal; to cure them we must practically influence it.

Myers's work on automatism led to his brilliant conception, in 1891, of hysteria. He defined it, with good reasons given, as "a disease of the hypnotic stratum." Hardly had he done so when the wonderfully ingenious observations of Binet, and especially of Janet in France, gave to this view the completest of corroborations. These observations have been extended in Germany, America, and elsewhere; and although Binet and Janet worked independently of Myers, and did work far more objective, he nevertheless will stand as the original announcer of a theory which, in my opinion, makes an epoch, not only in medical, but in psychological science, because it brings in an entirely new conception of our mental possibilities.

Myers's manner of apprehending the problem of the Subliminal shows itself fruitful in every possible direction. While official science practically refuses to attend to Subliminal phenomena, the circles which do attend to them treat them with a respect altogether too undiscriminating—every Subliminal deliverance must be an oracle. The result is that there is no basis of intercourse between those who best know the facts and those who are most competent to discuss them. Myers immediately establishes a basis by his remark that in so far as they have to use the same organism, with its preformed avenues of expression—what may be very different strata of the Subliminal are condemned in advance to manifest themselves in similar ways. This might account for the great generic likeness of so many automatic performances, while their different starting points behind the threshold might account for certain differences in them. Some of them, namely, seem to include elements of supernormal knowledge; others to show a curious subconscious mania for personation and deception; others again to be mere drivel. But Myers's conception of various strata or levels in the Subliminal sets us to analyzing them all from a new point

of view. The word Subliminal for him denotes only a region, with possibly the most heterogeneous contents. Much of the content is certainly rubbish, matter that Myers calls dissolutive, stuff that dreams are made of, fragments of lapsed memory, mechanical effects of habit and ordinary suggestion; some belongs to a middle region where a strange manufacture of inner romances perpetually goes on; finally, some of the content appears superiorly and subtly perceptive. But each has to appeal to us by the same channels and to use organs partly trained to their performance by messages from the other levels. Under these conditions what could be more natural to expect than a confusion, which Myers's suggestion would then have been the first indispensable step towards finally clearing away.

Once more, then, whatever be the upshot of the patient work required here, Myers's resourceful intellect has certainly done a service to psychology.

I said a while ago that his intellect was not by nature philosophic in the narrower sense of being that of a logician. In the broader sense of being a man of wide scientific imagination, Myers was most eminently a philosopher. He has shown this by his unusually daring grasp of the principle of evolution, and by the wonderful way in which he has worked out suggestions of mental evolution by means of biological analogies. These analogies are, if anything, too profuse and dazzling in his pages; but his conception of mental evolution is more radical than anything yet considered by psychologists as possible. It is absolutely original; and, being so radical, it becomes one of those hypotheses which, once propounded, can never be forgotten, but soon or later have to be worked out and submitted in every way to criticism and verification.

The corner-stone of his conception is the fact that consciousness has no essential unity. It aggregates and dissipates, and what we call normal consciousness—the 'Human Mind' of classic psychology—is not even typical, but only one case out of thousands. Slight organic alterations, intoxications and auto-intoxications, give supraliminal forms completely different, and the subliminal region seems to have laws in many respects peculiar. Myers thereupon makes the suggestion that the whole system of consciousness studied by the classic psychology is only an extract from a larger total, being a part told off, as it were, to do service in the adjustments of our physical organism to the world of nature. This extract, aggregated and personified for this particular purpose, has, like all evolving things, a variety of peculiarities. Having evolved, it may also dissolve, and in dreams, hysteria, and divers forms of degeneration it seems to do so. This is a retrograde process of separation in a consciousness of which the unity was once effected. But again the consciousness may follow the opposite course

and integrate still farther, or evolve by growing into yet untried directions. In veridical automatisms it actually seems to do so. It drops some of its usual modes of increase, its ordinary use of the senses, for example, and lays hold of bits of information which, in ways that we cannot even follow conjecturally, leak into it by way of the Subliminal. The ulterior source of a certain part of this information (limited and perverted as it always is by the organism's idiosyncrasies in the way of transmission and expression) Myers thought he could reasonably trace to departed human intelligence, or its existing equivalent. I pretend to no opinion on this point, for I have as yet studied the evidence with so little critical care that Myers was always surprised at my negligence. I can therefore speak with detachment from this question and, as a mere empirical psychologist, of Myers's general evolutionary conception. As such a psychologist I feel sure that the latter is a hypothesis of first-rate philosophic importance. It is based, of course, on his conviction of the extent of the Subliminal, and will stand or fall as that is verified or not; but whether it stand or fall, it looks to me like one of those sweeping ideas by which the scientific researches of an entire generation are often moulded. It would not be suprising if it proved such a leading idea in the investigation of the near future; for in one shape or another, the Subliminal has come to stay with us, and the only possible course to take henceforth is radically and thoroughly to explore its significance.

Looking back from Frederic Myers's vision of vastness in the field of psychological research upon the programme as most academic psychologists frame it, one must confess that its limitation at their hands seems not only unplausible, but, in truth, a little ridiculous. Even with brutes and madmen, even with hysterics and hypnotics admitted as the academic psychologists admit them, the official outlines of the subject are far too neat to stand in the light of analogy with the rest of nature. The ultimates of nature—her simple elements, if there be such—may indeed combine in definite proportions and follow classic laws of architecture; but in her proximates, in her phenomena as we immediately experience them, nature is everywhere gothic, not classic. She forms a real jungle, where all things are provisional, half-fitted to each other, and untidy. When we add such a complex kind of subliminal region as Myers believed in to the official region, we restore the analogy; and, though we may be mistaken in much detail, in a general way, at least, we become plausible. In comparison with Myers's way of attacking the question of immortality in particular, the official way is certainly so far from the mark as to be almost preposterous. It assumes that when our ordinary consciousness goes out, the only alternative surviving kind of consciousness that could be possible is abstract mentality, living on spiritual truth, and

communicating ideal wisdom—in short, the whole classic platonizing Sunday-school conception. Failing to get that sort of thing when it listens to reports about mediums, it denies that there can be anything. Myers approaches the subject with no such *a priori* requirement. If he finds any positive indication of 'spirits,' he records it, whatever it may be, and is willing to fit his conception to the facts, however grotesque the latter may appear, rather than to blot out the facts to suit his conception. But, as was long ago said by our collaborator, Mr. Canning Schiller, in words more effective than any I can write, if any conception should be blotted out by serious lovers of nature, it surely ought to be the classic academic Sunday-school conception. If anything is *un*likely in a world like this, it is that the next adjacent thing to the mere surface-show of our experience should be the realm of eternal essences, of platonic ideas, of crystal battlements, of absolute significance. But whether they be animists or associationists, a supposition something like this is still the assumption of our usual psychologists. It comes from their being for the most part philosophers in the technical sense, and from their showing the weakness of that profession for logical abstractions. Myers was primarily a lover of life and not of abstractions. He loved human life, human persons, and their peculiarities. So he could easily admit the possibility of level beyond level of perfectly concrete experience, all 'queer and cactus-like' though it might be, before we touch the absolute, or reach the eternal essences.

Behind the minute anatomists and the physiologists, with their metallic instruments, there have always stood the out-door naturalists with their eyes and love of concrete nature. The former call the latter superficial, but there is something wrong about your laboratory-biologist who has no sympathy with living animals. In psychology there is a similar distinction. Some psychologists are fascinated by the varieties of mind in living action, others by the dissecting out, whether by logical analysis or by brass instruments, of whatever elementary mental processes may be there. Myers must decidedly be placed in the former class, though his powerful use of analogy enabled him also to do work after the fashion of the latter. He loved human nature as Cuvier and Agassiz loved animal nature; in his view, as in their view, the subject formed a vast living picture. Whether his name will have in psychology as honorable a place as their names have gained in the sister science, will depend on whether future inquirers shall adopt or reject his theories; and the rapidity with which their decision shapes itself will depend largely on the vigor with which this Society continues its labor in his absence. It is at any rate a possibility, and I am disposed to think it a probability, that Frederic Myers will always be remembered in psychology as the pioneer who staked out a vast tract of

mental wilderness and planted the flag of genuine science upon it. He was an enormous collector. He introduced for the first time comparison, classification, and serial order into the peculiar kind of fact which he collected. He was a genius at perceiving analogies; he was fertile in hypotheses; and as far as conditions allowed it in this meteoric region, he relied on verification. Such advantages are of no avail, however, if one has struck into a false road from the outset. But should it turn out that Frederic Myers has really hit the right road by his divining instinct, it is certain that, like the names of others who have been wise, his name will keep an honorable place in scientific history.

THE POSE OF THE BODY AS RELATED TO THE TYPE OF THE CRANIUM AND THE DIRECTION OF THE VISUAL PLANE.*

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NEW YORK.

IT is a novel proposition that the position of the head in respect to the body or of the shoulders in reference to the back, that the carriage of the whole body in walking and the attitude of a person in conversation, should be governed in an important measure by the form of the cranium. It will also, doubtless, be regarded as a bold assertion to say that all these positions and attitudes and even the gait of individuals are largely modified, even in many instances controlled, by the normal position of the eyes in respect to the cranium. Yet it is not difficult to show that both these propositions are true and that the truth contained in these statements is not only of importance as a principle in art, but that it is of great practical value from the point of view of the well-being of large classes of persons.

From the standpoint of art the principle involved in these propositions shows the error of representing individuals who have certain forms of crania in attitudes which, for persons with those special cranial characteristics, would be unnatural and almost absurd. For example, when Thorwaldsen represented Sir Walter Scott with his chin elevated high in the air, he gave to the distinguished author of Waverley a posture of the head which would have been not only painful, but almost impossible for him to have maintained as a characteristic pose.

From the more practical and more important standpoint it may even be said that, owing to the position of the visual plane in respect to the head, there may be comparative immunity from certain complaints and diseases or a comparative predisposition to those very affections according to the type of the head and the direction of the normal plane of vision.

In order to facilitate the examination of the topic, it will be necessary to define some of the terms and some of the principles which enter into it.

The term 'normal plane of vision' will be used, and it should at the outset be understood exactly what is meant by the phrase.

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* An address delivered before the Section of Anthropology of The American Association for the Advancement of Science, at its session at Yale University, New Haven, December 27th, 1899.

By the term 'normal plane of vision,' as here employed, it is intended to express the direction which the lines of sight would assume, the head being in the erect, or more technically in what is known as the *primary,* position, in case no muscular effort should be made to change the eyes from an entirely passive adjustment.

Under these conditions the line of sight of each of the two eyes lies in an imaginary plane which may be coincident with, or somewhat higher than, or somewhat lower than, the plane of the horizon.

The *normal plane of vision* differs essentially from the *primary plane of regard* of Helmholtz and other writers, for this plane of regard refers to the plane formed by the two visual lines when these lines are directed toward the horizon, the head being in the primary position. The plane of regard is therefore unalterable. It was my own privilege to show that the normal plane of vision not only varies in different individuals but that, as a general rule, this variation is associated with and controlled by certain cranial characteristics which will presently engage our attention.*

This leads us to the consideration of certain types of the human cranium as they are recognized by craniologists.

While the form of the head of an individual may not be so clearly of one or another type that it must be classified as belonging to a certain group, in general, heads are grouped into three great classes or types, and these classes or types are again divided into subtypes. In this connection the subtypes need not be taken into consideration, but some knowledge of the main types is essential.

Craniologists, then, classify crania as *long, broad* and *medium.* Medium skulls, in order to avoid misconception, will be here designated as *tall* skulls, since the term medium does not, in this relation, refer to capacity, but to certain special measurements, and the accepted term might be misleading to those not well versed in the subject.

The basis for the classification consists of the proportion which the longest diameter from before backwards bears to the longest transverse diameter. If the transverse diameter is $^{75}/_{100}$ that of the longer diameter or less than $^{75}/_{100}$, the head is said to be in the class of long heads; but if the transverse diameter equals or exceeds $^{85}/_{100}$ the length of the skull, it is a broad skull. Medium skulls, or, as we are now to call them, tall skulls, are those in which the transverse diameter is between $^{75}/_{100}$ and $^{85}/_{100}$ and, as might be supposed, the measurement from the base of the skull to its summit, while it may not of itself be greater in an individual case than that of one of the long or one of the broad type nor even so great, is greater in proportion to the other measurements.

* The Normal Plane of Vision in Relation to Certain Cranial Characteristics. 'Archives of Ophthalmology,' Vol. xxvi, No. 3, 1897.

The diagrams, Figs. 1, 2 and 3, give the general outline of the form of heads of these types when looked at from above.

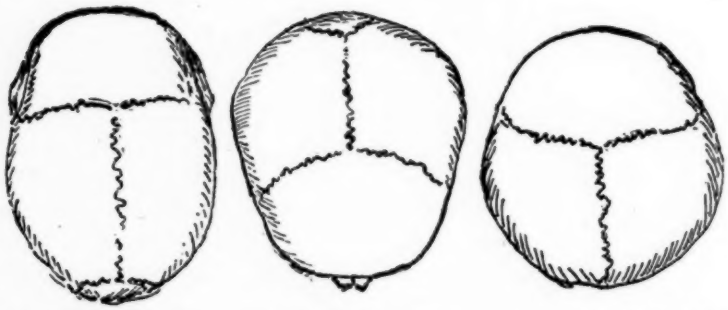


FIG. 1. THE LONG HEAD. FIG. 2. THE TALL HEAD. FIG. 3. THE BROAD HEAD.

In typical heads belonging to either of these types the outline of the face is likely to be characteristic of the type. Thus, the general outline of the face from the line of the brows to the tip of the chin as seen from the side differs, as a rule, according to the type of the cranium. Associated with the long cranium there is generally a convex facial outline, while a side view of the face of one from the class of tall heads shows usually very little or no curve. On the other hand the face of one from the class of broad skulls is likely to show a concave line.

The next series of figures, 4, 5 and 6, gives an idea of the general form from a side view of each of these three types in the living subject.

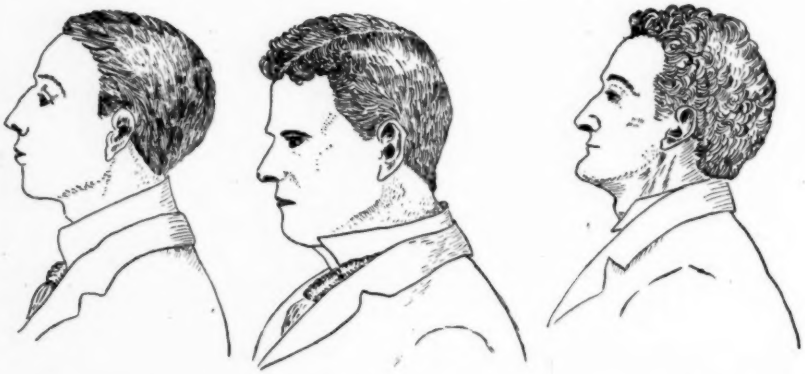


FIG. 4. THE LONG HEAD. FACIAL ANGLE + 10°. FIG. 5. THE TALL (MEDIUM) HEAD. FACIAL ANGLE 0°. FIG. 6. THE BROAD HEAD. FACIAL ANGLE —10°.

To nearly all general laws affecting the form of the human body there are exceptions, and the rule just stated is not absolutely uniform in its application. However, the type of head and the outline of face are generally in the relation shown by the diagrams.

In these three classes of crania the normal visual plane does not as a rule occupy the same position in relation to the horizontal plane, but varies according to the type of skull.

The relation of the normal visual plane to the type of the cranium in each of the three classes may be arrived at by direct and by indirect methods.

In the case of the living subject, the dimensions of the head may be taken and the plane of vision established in the same individual. The determination of the plane of vision in the living subject is accomplished through the aid of an instrument known as the tropometer. The relation is thus established by a direct method. The indirect method is that of ascertaining the direction of the imaginary line constituting the axis of the orbit in the prepared skull, the measurements of which are known. The orbits are more or less cone-shaped. If the extreme apex of the cone, at which the optic nerve enters it, is taken as one point of the line of the axis, and a point where two straight lines drawn at nearly right angles with each other from certain parts of the circle of bone constituting the outer border of the orbit cross is taken as another point in the line of the axis, the line which would pass through these two points would represent the axis. This imaginary line, if projected forward and beyond the orbit, would be seen in most cases to point somewhat downward, the skull being in the primary position, and in some types of skulls it points much more downward than in other types.

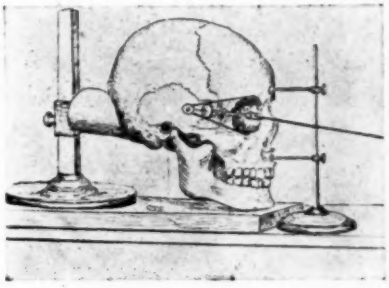


FIG. 7. THE AUTHOR'S METHOD OF DETERMINING THE AXIS OF THE ORBIT.

It is interesting to find that the pointing of the imaginary line representing the axis of the orbit closely corresponds with the observations on the normal visual plane in the living subject.

The interest is more considerable when it is found that the form of the orbit in the different classes of skulls offers an explanation of the peculiarities in the direction of the orbital axis, as well as of the normal plane of vision.

Figs. 8, 9 and 10 represent the front views of skulls of the long, tall and broad types respectively, showing the form of the orbit corresponding to each type. It will be seen that in the long skull (Fig. 8) the roof of the orbit is much lower than that of the tall skull (Fig. 9) and that the lower border extends more downward. The orbit of the tall skull is not only placed with its opening higher, but it is more narrow from side to side. In the case of the broad skull (Fig. 10) the

roof of the orbit is low like that of the long skull, but the lower border does not extend so far downward and the direction of the transverse diameter is more oblique.

Measurements of the direction of the axis of the orbit in these three classes show that in the long skull the direction is usually quite

FIG. 8.
FRONT VIEW OF LONG SKULL: CEPHALIC INDEX 71.4 : 100.

FIG. 9.
FRONT VIEW OF TALL SKULL: CEPHALIC INDEX 81 : 100.

FIG. 10.
FRONT VIEW OF BROAD SKULL: CEPHALIC INDEX 85 : 100.

low, that in the tall skull it is much higher and that, while the axis of the broad skull is lower than that of the tall one, it is scarcely as low on the average as in the case of the long skull; and these comparative positions of the axes of the orbits in the prepared skulls correspond remarkably with the positions of the visual plane in the case of living subjects with heads of corresponding types. That is, the visual plane of the long head is low, of the broad head also low and that of the tall head is high.

Notwithstanding the apparent simplicity of these relations of the form of the orbit with the type of the skull and of the direction of the visual plane to the type of cranium, there are, in practice, certain modifying features.

The most important of these from the anatomical standpoint is found in the angle of the face. In forming a judgment, therefore, of the probable direction of the normal visual plane in the living subject without resorting to measurements by the tropometer, it is necessary to measure or to estimate this angle. None of the measurements employed for the prepared skull will serve the purpose here, and it has been found most practical to use for fixed points for the measurement of this angle the following: the glabella, which is the elevation above the root of the nose and just between the ridges of bone above the orbits; the depression just below the nose, and the tip of the chin.

If these three fixed points are selected for the measurement of the angle of the face, it will readily be seen that this angle varies greatly in different individuals. It may, indeed, vary considerably in heads belonging to the same type. Yet, on the whole, there is a pretty

general association between the character of the face and the type of the head.

In the case of the long head, for example, the angle is external, as will be seen on turning to the diagram, Fig. 4, in which the facial angle is plus (+) 11°, or to Fig. 14 where it is plus (+) 15°. In the broad head, on the contrary, the angle is likely to be inverse, as in Fig. 6 where the angle is minus (—) 10°. In the tall head, however, the facial angle almost vanishes. It is, in general, 0° as in Fig. 5 or only an angle of from + 2° to + 4°, rarely exceeding + 6°. But, as already intimated, the angle may vary in each type of head.

FIG. 11. STEVENS'S FACIAL GONIOMETER.

Now, if the angle of the face is taken in connection with the type of head, we have a fairly certain indication of the direction of the plane of vision.

With the long head and strong external facial angle the plane of vision is almost invariably low. With the broad head and inverse angle the visual plane is also low, but there is a restricted downward range of the rotations of the eyes, notwithstanding this depressed position of the visual plane. With the tall head and straight face the plane of vision is high and in proportion as the head is comparatively tall it may be very high.

When these elemental principles are once understood it is not difficult to comprehend the phenomena to which they give rise.

Thus it is easy to see that a person whose normal plane of vision is quite low finds it easier to throw the head backwards, lifting the chin and forcing the forehead back, than to raise the visual plane to the level of the horizon or even to the lower plane which the eyes assume in walking, if that visual plane has to be thus elevated and the elevation maintained for some time by the delicate muscles which act directly in elevating the eyes.* On the contrary one whose visual plane is very high prefers to throw the forehead in advance and the chin into the breast rather than maintain a tension upon the little muscles which act directly upon the eyes to pull them down.

Thus it will be seen that the person represented at Fig. 12, with the long head (from before backward) and the strong angle of the face, carries the forehead quite far back and the chin well up, not from

* There is more in this statement than would at first appear, for the important question of the horopter must be included here, but this would add an element too extensive for present discussion.

any affectation of attitude, but because it is less wearisome to the eyes to assume this position. As a matter of fact this person's eyes were normally adjusted 10° below the plane which has been found to be the

FIG. 12.

FIG. 13.

best and which may be called the standard plane. On the contrary the person whose pose is represented at Fig. 13, whose head is high compared to its transverse and horizontal diameters, a head which is neither of the long nor broad type, but of the medium (tall) type with the absence of a strong angle of the face, had the plane of vision very high. Such a person prefers to throw the forehead in advance and the chin into the breast, rather than make a continual and somewhat tiresome effort to draw the eyes to the proper plane by direct tension upon the depressor muscles of the eyes.

It is not difficult to see that this selection of the easiest method of adjusting the lines of sight to surrounding objects exercises a commanding influence on the whole pose of the body.

While the rule generally holds that the form of the skull and therefore the form of the orbit governs the direction of the visual plane and hence also the pose of the head and of the body, there are other elements which enter into the case and give rise to exceptions. The most important of these modifying elements is the condition known as the 'declination of the vertical meridians of the retina';* still, in order

* The subject of the horopter has already been referred to in the note to page 395. In regard to declinations, while it would be impossible to enter upon that complex subject here, it would be misleading were we to pass it by without the statement that the pose of the head is sometimes governed, even against the rule which it is sought here to point out, by the direction of the retinal meridians and hence in practice a knowledge of this subject would be essential to a full understanding of the subject under discussion.

to avoid taking too wide a range of discussion, we shall treat the subject as though the influence of the plane of vision were in all cases uniform, which is not strictly the case; yet, for our present purpose, we may omit the exceptions, and the statements that follow must be accepted as general and as including the proviso, other things being equal.

Examining then the pose of the head and body in their relations to the position of the visual plane more in detail, it will be found that when the visual plane is quite low not only is there a tendency for the individual to elevate the chin and throw the head back, but the muscles of the whole back, even those of its lower part, are put in a state of tension. This tension is so considerable that in a great many instances among persons who are not very strong the resulting habitual pains of the muscles engaged are often mistaken and treated for diseases of internal organs or of the spine year after year.

An element of the facial expression with this direction of the visual plane is the pronounced elevation of the brows upon the forehead and the somewhat drooping appearance of the eyelids (see Fig. 4). There are other facial expressions characteristic of this depressed plane of vision which may be passed over in this connection.

The attitude and gait of the individual are also generally influenced by the downward direction of the visual plane. In walking the shoulders are thrown back and the chest is thrust forward. The foot, in many cases, swings forward considerably beyond the limit of the completed step, so that it is drawn somewhat backward as it comes to the ground.

While persons of this class are more liable than others to certain physical complaints and nervous disturbances which can be traced directly to this ocular condition than are those whose eyes are adjusted for a higher plane, they are, on the other hand, compared with this latter class far less subject to certain other forms of diseases and affections.

A single example will serve to illustrate this proposition. Although the illustration relates to a trouble with the eyes themselves it would be easy to present many examples to illustrate immunity of the same class of persons from a variety of more general affections.

A few years since a distinguished oculist of one of our southern cities announced that trachoma, that form of eye trouble commonly known as granular lids, and which is one of the prolific sources of blindness, is unknown among pure negroes. The discussion of this proposition, after occupying the attention of oculists for some time, was at length taken up in a different way by a distinguished colleague in Constantinople.

This gentleman wrote to oculists in all parts of the world asking

for the results of their observations in their own countries in regard to all classes of people. He at length published a symposium of the answers showing the prevalence of trachoma in different countries and among the different classes of people. As given in this contribution there seemed to be a confused accumulation of facts which had, on the whole, apparently little meaning. Peoples of contiguous countries, of the same color and not very different in habits of life, were reported as differing widely in respect to the prevalence of the affection. No reasons were assigned and none seemed to be suggested by the varying facts. An analysis which I made of this report showed that among peoples with the 'medium' or tall heads, like the Irish and the Italians, trachoma is rife; while among peoples with the broad head, like the Bavarians, or with the long head, like the negroes whose ancestors were from the West or Guinea coast of Africa, trachoma did not prevail; but it is interesting to note that descendants of the negroes of the northern part of Africa, where the heads of the natives are often tall, are subject to trachoma equally with the whites among whom they live. I have in another connection discussed this question at more length.*

FIG. 14. THE LONG HEAD WITH PROGNATHOUS FACE. FACIAL ANGLE +15°.

A glance at Fig 14 will show that the negro as he is known in our Southern States not only throws the head backward in the manner characteristic of the long head, the strong facial angle and the depressed visual plane, but that the eyebrows are characteristically elevated. This drawing up of the brow is accompanied with a drawing upon the lids and hence no pressure is brought upon the surface of the eyes by the upper lids. In the case of the tall head with the high plane of vision the brows are strongly compressed and the lids bind upon the eyeball and thus in the midst of dust and filth or even in good sanitary surroundings disease of the lids may be promoted.

Reverting once more to the declinations of the retinal meridians, the same effect may be induced both as to the pose of the head and the relaxed state of the lids. It is, however, impracticable to consider the subject from that point of view at present.

Turning to a larger and more important subject, the negro is known to be especially subject to tubercular diseases, yet he is, to an unusual degree, immune from consumption. In my investigations during the past few years, I have not seen a consumptive the direction of whose visual plane was not much higher than the standard. We shall come to this from another point of view. It is easy to see that

* 'Transactions of the British Medical Association,' 1897.

the principle which applies in the case of the long skull applies similarly also in that of the broad skull although, in general, in somewhat less degree.

People who have broad heads with inverse angle of the face usually carry the head with the forehead thrown back and the chin elevated. Those who have this form of head and this consequent depression of the visual plane often suffer from the neuralgic or myalgic affections of the back of the head and the spinal region like the class with the long head and strong exterior facial angle. The differences need not be discussed here.

Directing our attention now to the excessive upward direction of the plane of vision which is found principally with the tall, or more correctly and technically, the mesocephalic head, we find not only a great difference in the adjustments of the facial muscles as compared with the class which we have just considered, but also in the poise of the body. In the class now to be considered the brows are compressed and the expression is one of intensity. The chin is not elevated as in the other class, but the forehead is advanced and the body leans forward. The shoulders bend forward and the chest is often compressed. With the noblest form of the head comes a stoop of the body. Fortunately for the world these people do not all have consumption, for if they did one of the highest forms of development of humanity would be wiped out. Unfortunately, however, it is from this class of people that consumption finds the great majority of its victims. Glance at the position of the air passages in these two portraits in each of which the habitual pose of the body and head is fairly represented.

FIG. 15.

FIG. 16.

In the case of the one with the broad head and difficult upward rotations of the eyes (Fig. 15), a swarm of tubercle bacilli would pass in and out of the respiratory passages with much the same effect as any

other minute particles of dust, while in the case of the tall headed boy (Fig. 16) who has, by actual measurement, the visual plane adjusted more than twenty degrees above the horizon, the larynx forms a hinge-like valve and in the quiet eddies of a lung under these circumstances the tubercle bacilli can easily hold high carnival. If the direction of the large branches of the air tubes is considered it is evident that the circulation of the air in the very upper portions of the lungs of one with such a habitual pose would naturally be even less active than in the lower parts, and it is interesting to remember that it is in the upper lobes that the bacilli usually commence their inroads. The modern treatment of consumption is fresh air. It is evident that the amount of air admitted to the lungs of a person with the habitual attitude of this boy must be very materially modified by this position of the head; and could the normal pose be improved he would by that means be subjected to the fresh-air treatment. It will be seen that this is entirely practicable.

The comparative immunity of the negro race from consumption has already been referred to, and it is a fact of much practical interest that among the people of Iceland, people with the extreme broad head and with the characteristic pose, the head thrown back, the chin elevated, consumption is unknown. Yet these people habitually inhale the most vitiated atmosphere, an atmosphere which, habitually inhaled by the people of this country, would induce an epidemic of consumption which would be of the most devastating character.

As the general pose of the head and the attitude of the body differ in the class with high heads from those of the other classes, so the gait and carriage of these people differ widely from those of the others. If the cake walk is an extravagant exaggeration of the walk of the classes with the low visual plane, the stoop of Shylock as it is represented on the stage is the exaggeration of the carriage of the other class.

This is but a most cursory glance at a most important subject; and the affections and characteristics mentioned are but a group of those whose name is legion and which have for their cause one or other of these visual conditions.

Several years ago attention was called by the writer of this article to the one-sided carriage of the head of those who have the visual line of one eye higher than that of the other. I will only refer to it here as one of the elements in this interesting subject.

The practical question which arises from the presentation of this subject is: Can the direction of the visual axes be so modified in the individual case as to change the pose of the head and body so as to relieve the person from the results of his physical peculiarity? To this an emphatic affirmative answer can be given. The eyes can be adjusted for any desired plane by a safe and speedy procedure. It may be said

that, in the hands of one specially skilled in this procedure, the inconvenience and risk are scarcely as great as those resulting from vaccination as commonly practised.

Thus, by practical and judicious methods, the unfortunate positions of the eyes due to the hereditary form of the orbits may be rectified, and the handicap with which large classes of persons enter upon the course of life may be removed, thereby offering them that advantage and that staying quality in the contest for welfare and for success to which, by their native strength and inborn abilities, they are fairly entitled.

THE GREAT MORTALITY.

By PROFESSOR EDWARD P. CHEYNEY.

IN every city of the civilized world to-day, armed and watchful men are standing on guard against a dreaded invader; men armed with knowledge obtained from scientific investigation, with experience drawn from former attacks, with authority of law to enter every household and set aside every individual claim in the work of resistance to the first onset of the foe. This anticipated enemy is the bubonic plague, and the officials of boards of health form a civic guard against it more nearly impassable than any military cordon. Yet with all this watchfulness, with the expenditure of vast sums in delimitation and extirpation, with the relatively cleanly surroundings of daily life in this century, the plague has within the last five years broken through the barriers and made its way into various cities of Asia, Africa, Australia, Europe and North and South America. Not only in its indigenous home in India, but in Sydney and Honolulu, in Lisbon and Rio de Janeiro, in Glasgow and San Francisco, in Cairo and Cape Town, it has made a longer or shorter lodgment.

There was a time when there was no such guard against invasion, when the same disease passed westward from its Asiatic birthplace in a fierce attack upon the nations of Europe, and found no measures taken to resist its advance; indeed, in the squalid houses and streets of medieval towns and villages, there was every inducement to enter and batten on populations unfitted by habits of life or by medical knowledge to expel, resist or even mollify their enemy.

"In the year of grace 1349," an old chronicle says, "a great mortality of mankind advanced over the world; beginning in the regions of the north and east and ending with so great a destruction that scarcely half of the people remained. Then towns once full of men became destitute of inhabitants, and so violently did the pestilence increase that the living were scarce able to bury the dead." So sudden, so mysterious, so fatal was this pestilence that even the dry medieval annalist personified it, spoke of it as if it were some active sentient personality. "Very many of those who were attacked in the morning it carried out of human affairs before noon; and no one whom it willed to die did it permit to live longer than three or four days."

Friar Clyn, in his 'Chronicle of Ireland,' after giving many details of the plague, says: "I, therefore, brother of John Clyn of the order of

the Minors and the convent of Kilkenny, have written down in this book these wonderful occurrences of our time as I have seen them with my eyes or heard them from credible witnesses; and lest such strange things should perish with the passage of time and should pass from the memory of men who are to come, watching these many evils and the whole world fallen into sickness, and waiting among the dead till death shall come, I have put into writing what I have heard truthfully and observed carefully. And lest the writing should perish with the writer and the labor should fail with the laborer, I leave parchment to continue the work, if it should chance that any man should survive, or any of the race of Adam succeed in escaping this pestilence, to continue the work which I have begun." Then follow two or three confused sentences, when his expectation of death must have been justified, for there is nothing more of the chronicle except an annotation by a later hand, *videtur quod auctor hic obiit,* 'it seems that the author here died.' Another chronicler lays down his pen at the onset of the plague, and long afterward when resuming his narrative, sick at heart, perhaps, or feeling his skill inadequate to the description of such a period of confusion, enters in the appropriate place only the words *magna mortalitas,* 'the great mortality.'

This great mortality came 'from the north and east.' On the confines of Asia and Europe, at the mouth of the Sea of Azov, lay the medieval trading city of Kaffa. Here goods were brought from Persia, from India and from China to be handed over by men of the east to men of the west. Genoese and Venetian bought from Tartar and Arab silk, cotton, spices, precious stones and metals, gums, woods and sugar, and carried them through the Black Sea and the Mediterranean to be distributed finally among all the countries of Europe. In the year 1347 a war broke out in the Crimea between these men of the west and of the east, and the Italian inhabitants of Kaffa were besieged by the Tartars. In the midst of the hostilities a terrible pestilence broke out among the besiegers, which devastated their hordes like the hand of the destroying angel in the camp of the Assyrians. In their frenzy the survivors threw numbers of the bodies of those who had died of the plague from their catapults into the besieged city and thus carried infection to those within. The siege was soon raised, and the Genoese merchants and sailors, resuming their trading, set sail toward the west. But they took with them on their voyage, along with the luxuries from the far east, a new scourge for Europe, the contagion of the plague—the Black Death, as it has been called in modern times.

The symptoms of the disease were obscure and varying, and so remained through successive attacks, until only too abundant opportunities for observation have recently enabled modern medical observers to

differentiate its various types. But it showed itself then, as it still remains, fatal in a greater proportion of cases than any other disease to which humanity is subject.

The distribution of its germs through the Mediterranean lands was quickly accomplished. In the fall of 1347 Constantinople was more than decimated. The shores of the Ægean were quickly infected, and before the close of the year Sicily, the cities and towns of southern Italy, and all the ports of the Adriatic were alike prostrate under the scourge. A Sicilian tells how "a most deadly pestilence sprang up over the entire island. It happened that in the month of October, in the year of our Lord 1347, about the beginning of the month, twelve Genoese ships flying from the divine vengeance which our Lord for their sins had sent upon them, put into the port Messina, bringing with them such a sickness clinging to their very bones that, did anyone speak to them, he was directly struck with a mortal sickness from which there was no escape. Flight profited nothing, for the sickness already contracted and clinging to the fugitives was only carried wherever they sought refuge. Some of those who fled fell on the roads and dragged themselves to die in the fields, the woods, the valleys."

By the springtime the storm had spent its fury in the south of Italy, but it had passed on northward. It was in April of 1348, Boccaccio tells us, that the malady appeared in the fair city of Florence. There while human nature was resolved into its most primitive elements, as he describes in the introduction to the Decameron, his little group of story tellers gathered in a country house about two miles outside of the city trying to avoid the pestilence, or at least to make what time should remain pass more cheerfully in the recounting of sad or merry tales. The occasional pathos, the frequent salacity, and the unvarying humor and grace of the tales stand out boldly in Boccaccio's setting of them against the dark background of the mournful remembrance of that most fatal plague so terrible yet in the memories of us all. In the city the sick were lying deserted by friends, family, servants, physicians and even by the priest, as implacable death crept upon them; palaces stood deserted and unfastened, jewels and rich garments lying unguarded, except by the dread of infection; the bodies of the dead were being hastily dragged from the houses, carried to the cemeteries and deposited in long rows in pits, with no bells rung, no rites said, no solemn chant or mourning of friends; while outside the city the story tellers of the Decameron were passing away the time governed by the one rule that none should bring to them any news of the plague-stricken outer world.

Not only Boccaccio in Florence, but Petrarch in Parma, writes in the midst of the plague: "Where are now our pleasant friends? Where the loved faces? Where their cheering words? Where their

sweet and gentle conversation? We were surrounded by a crowd of friends; now we are almost alone." And he might well see the world darkening around him, for had not Laura just died of the plague at Avignon? The 'great mortality' was indeed no respecter of persons. It is true that the poor died in greater numbers in proportion to the closeness and insalubrity of their dwellings and to their lack of power of resistance from insufficient food. But the list of the great ones of the earth who died is a long one. One of the earliest victims of the plague on its entrance into Europe was Andronicus, the son of the Emperor at Constantinople. The King and Queen of Arragon both died from it. Joan, the daughter of Edward III., on her way to Castile to be married, was smitten suddenly at Bordeaux and died, escaping, it is true, the worse fate of living to be the wife of Pedro the Cruel. Great churchmen died in all parts of Europe—the archbishop of Cantania, the archbishop of Canterbury, the archbishop of Drontheim; bishops and abbots in every country. Of the twelve city magistrates of Montpellier, in France, ten died; of the twenty-four prominent physicians, twenty. Nobles and burghers, ecclesiastics and lawyers fared but little better than the great masses, except that their names are mentioned, while the hundreds of thousands of lesser men died unknown.

The Mediterranean was then still the middle of the world, and the pestilence, like art and literature and money, was distributed readily from Italy to all parts of Europe. Before the year 1348 was over it was in France, Switzerland and Germany, and had obtained a foothold in the southern seaports of England. The next year it passed still further northward through England, Scotland and Ireland. It was carried from England to Scandinavia by a London ship, all of whose crew died, leaving the boat with its fatal cargo to be cast on the Norwegian coast at Bergen. During the same year and the succeeding spring, it had passed down the Valley of the Rhine, through the Netherlands and northern Germany, until the year 1350 saw 'the great mortality,' its harvest reaped for that season, passing out of the northern and western portals of Europe to the all-purifying waters of the great ocean.

But during those four years of devastation what experiences had humanity gone through! We can look back now and see only dimly through the mist. The figures are blurred and their movements indistinct. The light of imagination fails to illuminate a condition so different from normal experience. Only here and there a clear light is cast upon some spot by a record made at the time. In the inn of a little town in Spain a French pilgrim returning from the tomb of St. James of Campostella, after supping with the host, who with two daughters and one servant had alone so far survived of his entire family and

who was not then conscious of any sickness upon them, settled with him for his entertainment, intending to start on his journey at daybreak, and went to bed. The next morning, rising and wanting something from those with whom they had supped, the travelers could make no one hear. Then they learned from an old woman whom they found in bed that the host, his two daughters and servant had died in the night. "In the spring of 1348 a Genoese, infected with the plague, came to Piacenza. He sought out his friend, Fulchino della Croce, who took him into his house. Almost immediately afterward he died, and the said Fulchino was also quickly carried off with his entire family and many of his neighbors." "The bishop of Rochester out of his small household lost four priests, five gentlemen, ten serving men, seven young clerks and six pages, so that not a person remained who might serve him in any office." "Alas, for our sorrow! This mortality swept away so vast a multitude of both sexes that none could be found to carry the corpses to the grave. Men and women bore their own offspring on their shoulders to the church and cast them into a common pit." "And I, Agniolo di Tura, carried with my own hands my five little sons to the pit."

Everywhere through Europe the story is the same. The sudden onset, the four or five months of devastation, the glutting of the old cemeteries and the opening up of new, the pits into which the bodies were piled, the extermination of whole families, the collapse of government, the desertion of the sick and the dead, the avoidance of the infected, the occasional heroism, self-sacrifice, devotion to duty, and the sadly more frequent selfishness, cruelty, callousness and recklessness; then the passing away of the visitation, leaving behind it, often, according to the bewildered judgment of the contemporary chronicler, not a tenth part of the people, and even according to modern and moderate computation seldom as many as one-half of the population it had found.

Then came the gleaning. Physical disease then as always brought moral degeneracy. A great catastrophe then as always weakened the virtues and strengthened the vices of poor custom-bound humanity. A physician at Avignon writes: "The father did not visit his son, nor the son his father. Charity was dead." Villani says of his neighbors at Florence that they behaved as "might perhaps be expected from infidels and savages." "Men gave themselves up to the enjoyment of the worldly riches to which they had succeeded." The English manor court rolls record more than one case where a house bereft of its occupants by the plague was plundered by the neighbors, and bodies of the dead stripped by their own fellow villagers. The wealthy, in the months following the plague, gambled, reveled, steeped themselves in gluttony and lechery; the poor idled, brawled, took advantage of the

necessities of their lords, and became irreligious and rebellious. Scarcely a writer fails to record the utter selfishness of the period of the visitation and the dissoluteness and lowered morals which followed in its wake. The surviving laborers insisted on higher wages, and employers used their influence with the Government to pass laws to compel the acceptance of the old rates. Contention raged between rich and poor, and the seeds were sown for Jacqueries and Peasants' Rebellions. The building of churches ceased for a time. The newly laid foundations of the vast nave and choir of the cathedral at Siena were left as they were and have never been built upon to this day. A thousand partially built churches remained stationary for a time, and their construction was resumed only when architectural style had changed so distinctly that the line of division can still be seen. At Oxford and Cambridge and Paris the number of students was depleted and never again rose to its former number. The clergy suffered more than any other class in the community. Many a monastery had lost its whole body of occupants. In others the few survivors, with diminished income from their land and weakened devotion and discipline because of the death of their leading members, never refilled their numbers or regained their old prosperity and vigor. The bishops were compelled to ordain to the service of the church the young, the inexperienced, the illiterate; and even then there were too few for its needs.

Society gradually reconstructed itself on much the same old lines. Permanent changes come not from sudden and conspicuous, but from slowly acting and obscure, influences. Yet Europe was never quite the same again. Two centuries may have passed before the void in medieval population was refilled. Even to this day grain ripens yearly over the sites of villages which lost their population and their name in the great mortality. Various social changes were hastened or retarded or deflected from their former direction. Even though there was no actual breach in the continuity of European development, yet new interests arose, new evil and new good appeared. 'Sithence the pestilence' is an era which Piers Plowman quite naturally uses; for it was graven deep in the memory of his generation.

DISCUSSION AND CORRESPONDENCE.

GEOLOGY AND THE DELUGE.

To the Editor:—I have read with much bewilderment an article entitled 'Geology and the Deluge,' contributed to 'McClure's Magazine' for June, by Dr. Frederick G. Wright, professor of the harmony of science and religion in Oberlin College. Doubtless other men of science would also be gratified if Professor Wright would consent to make his position clear by answering the following questions:

1. You say, Professor Wright, that "The Paleolithic man of science may well be the Antediluvian man of Genesis." Was Tubal Cain, 'an instructor of every artificer in brass and iron,' an antediluvian man, and, if so, had he not learned to use smoothed stone instruments? Was Noah, himself, a paleolithic or a neolithic man, and did he build the ark with flaked or polished flint implements?

2. You say: "But towards the close of this period there were 120 years (specially mentioned in the Bible as a time of warning) in which the movement was accelerated to such a degree that the rising waters gave point to the preaching of Noah." The period of 120 years here mentioned was deduced from the statement that Noah was 600 years old at the time of the flood. Do you believe that Noah was 600 years old, and that his grandchildren that peopled the earth were subsequently born?

3. You say: "During the last 371 days of this period the catastrophe culminated in the facts specifically related in the Book of Genesis." Do you believe that the 'facts specifically related in the Book of Genesis' are true? For example, that "every living substance was destroyed which was upon the face of the ground, both man, and cattle, and the creeping things, and the fowl of the heaven; and they were destroyed from the earth: and Noah only remained *alive*, and they that *were* with him in the ark."

The readers of 'McClure's Magazine' will probably understand that Professor Wright claims to have confirmed by his geological discoveries the details related in Genesis. Are Professor Wright's fellow geologists also to understand that he believes that the early chapters of Genesis are in accord with modern science and that they are supported by his recent observations in Asia?

X. PLAIN.

ETHER AND CHLOROFORM.

To the Editor:—In the course of an article on 'Cocaine Analgesia of the Spinal Cord,' in the July number of the POPULAR SCIENCE MONTHLY, Dr. Jelliffe writes, "Soon after chloroform came ether, the safer anæsthetic," etc. Ether was, however, introduced before chloroform. On September 30, 1846, Morton, of Boston, used ether in dental surgery, and during the following months it was administered in surgical operations at the Massachusetts General Hospital. The news reached England on December 17, 1846. It was used by Simpson, of Edinburgh, in midwifery practice in January, 1847, and it was not until November, 1847, that he announced the discovery of the anæsthetic properties of chloroform.

C. HERRMAN.

SCIENTIFIC LITERATURE.

RECENT CONTRIBUTIONS TO ENGINEERING.

'TUNNELING: A Practical Treatise,' by Charles Prelini, of Manhattan College, is a well-printed book, just published by D. Van Nostrand Company, which appears to fill a real need, since no American work on the subject has appeared during the past twenty years. The various methods of driving tunnels through earth are fully illustrated, especial attention being given to the shield process which has been so thoroughly developed in recent years. Submarine tunnels are discussed fully, with illustrations of those in New York, Chicago and Milwaukee. Tunnels in rock occupy nearly one-half the volume, the modern methods used in the St. Gothard and Simplon tunnels receiving detailed notice. Subway construction in Boston and New York is also discussed. Interesting historical information regarding ancient tunnels is given, while methods of surveying, centering, blasting and ventilating are explained in a manner which sets forth principles as well as facts. The book is one that shows much painstaking work on the part of the author, and it deserves high commendation.

IN ancient times it was the custom for the title page of a book to give a full account of its contents. This plan is followed in a work by James D. Schuyler, published by Wiley & Sons, whose title is 'Reservoirs for Irrigation, Water Power, and Domestic Water Supply, with an account of various types of dams and the methods and plans of their construction, together with a discussion of the available water supply for irrigation in various sections of arid America; the distribution, application and use of water; the rainfall and run-off, the evaporation from reservoirs, the effect of silt upon reservoirs, etc.' The volume is a large octavo of 400 pages with numerous full-page half-tones and several folding plates. It is mostly devoted to constructions west of the Rocky mountains; here hydraulic-fill dams and rock-fill dams originated, and the book contains descriptions of all that have been built, as well as accounts of the most important masonry and earthen dams. The treatment is descriptive and statistical rather than scientific, and the work is hence mainly one of reference for the use of engineers.

'THE CEMENT INDUSTRY,' published by the 'Engineering Record,' is an octavo volume of 235 pages which gives detailed descriptions of numerous cement plants in Europe and America. The production of natural cement in the United States has been somewhat checked during the last decade by the rapid improvements in the manufacture of the Portland product, particularly by the introduction of rotary kilns. From 1895 to 1900 the production of Portland cement increased from one to seven million barrels per year, and the price suffered a reduction of nearly fifty per cent. The great deposits of argillaceous limestone in the Lehigh Valley form the principal source of Portland cement, but in the west it is made by mixing clay and marl in proper proportions, and there are also two or three plants where blast-furnace slag is used. The book, which is well illustrated, gives full details of the methods of manufacture of both natural and Portland cements.

A MONTHLY journal called 'Revista de Construcciones y Agrimensura' is published monthly at Havana by Aurelio Sandoval. It contains many excellent plans and illustrations of buildings, articles on road and railroad construction, surveying, mechanics and technical education, and appears to be edited with much care. The last number contains the questions propounded to the candidates for chief of the mechanical laboratory in the engineering department of the University of Havana, and these indicate that a high scientific and technical standard is demanded as a qualification for a professorship. The University of Havana was completely reorganized in 1900, under an order issued by Gen. Chaffee, and the previously independent school of engineering made one of its departments under the faculty of letters and sciences. The university recently conferred its first degree of Civil Engineer upon Sr. Andrés Castella, who had the highest rank in an examination held for an assistant professorship in engineering.

'THE ECONOMIC DISPOSAL OF TOWNS' REFUSE,' by W. Francis Goodrich, is one of the 'Engineering Times' Library, published by King & Son, London. The author holds that garbage and street sweepings should be destroyed by fire and in no other way, and he presents facts and figures from all countries showing the great growth of processes of cremation. Dumping street refuse at sea, sorting it out into parts which may be utilized, and the processes of reduction by boiling are summarily dismissed as unworthy of consideration. The volume contains a large amount of information regarding different kinds of crematories, with results of comparative tests, and also a lengthy discussion as to the best kind of chimneys and boilers to utilize the hot waste gases for the purpose of generating power. Cremating furnaces are now in operation at 106 towns in England, there being 18 in London alone, and at 12 towns in Scotland and Ireland. At Bradford, Canterbury, Fleetwood, Oldham and a few other places, the waste gases are utilized for producing electric power for street lighting.

'PUBLIC WATER SUPPLIES,' by Professors F. E. Turneaure and F. H. Russell (John Wiley & Sons), is a comprehensive work covering the entire range of the subject, sanitary as well as constructive. That certain diseases are communicated through water is now thoroughly established, and the demonstration that the water can be rendered harmless by proper filtration is complete. Hence purity as well as quantity is an important factor in the consideration of a modern water supply. The chemical and bacteriological part of such works has heretofore been generally kept aside from the engineering part, but by the cooperation of two authors, both specialists in their respective lines, the difficult task of coordination has been here attempted. The book is mainly designed for engineering students in technical schools, but it cannot be said that the chapters on the chemistry and bacteriology of water are written in such a manner as to produce the best results. The engineering discussions relating to filter beds, walls, reservoirs, mains, standpipes and other details seem, on the other hand, to be clear and complete and likely to be of interest and value to all engaged in planning water supplies. The volume is the largest yet published on this subject in this country, is well printed with the exception of some of the cuts, and contains many carefully prepared descriptions of constructed plants. That the authors have not been completely successful in combining the sanitary and constructive elements is not surprising, in view of the difficulty of the task, but they deserve great credit for their painstaking work and the valuable volume produced.

THE PROGRESS OF SCIENCE.

THE WASHINGTON MEMORIAL INSTITUTION.

It is generally though not universally known that Washington made provision in his will toward the establishment of a national university. For reasons somewhat difficult to understand his bequest has never been used, and only after the lapse of a hundred years has an institution been established in his memory which will fully accomplish under the conditions now existing the great objects he had in view. These have, it is true, in large measure been met by the growth of private and state universities, and by the development of scientific work under the government, but at last these different lines will converge in the Washington Memorial Institution. This has resulted from the union of more or less independent efforts. An enthusiastic group of men and women has long advocated the establishment of a national university, and for this purpose a George Washington Memorial Association was incorporated in 1898. In the same year the Washington Academy of Sciences was organized, giving a definite center for scientific interests in the city and to a certain extent throughout the country. In the same year a committee of the National Educational Association was appointed, which recommended the utilization for research of the scientific and other departments of the government. In the same year a committee of the Association of Agricultural Colleges and Experiment Stations recommended the organization of opportunities for study and research for students of the land grant and other colleges. The year 1898 is consequently an important one in the history of the development of education and research in the United States, and the present year marks the union and fruition of these efforts.

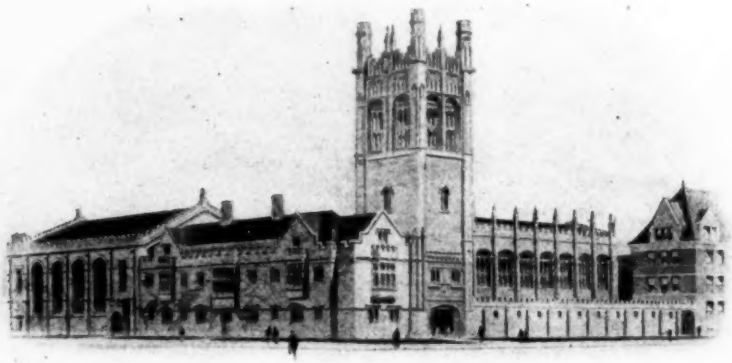
The Washington Memorial Institution was incorporated on May 20, its objects being defined as follows:

> To create a memorial to George Washington, to promote science and literature, to provide opportunities and facilities for higher learning, and to facilitate the utilization of the scientific and other resources of the government for purposes of research and higher education.

A board of fifteen trustees has been created, including representatives of the leading universities of the country and of the scientific work under the government. The officers include Dr. D. C. Gilman, lately president of the Johns Hopkins University, as director; Dr. Charles D. Walcott, president of the Washington Academy of Sciences and director of the U. S. Geological Survey, as president of the board of trustees; and Professor Nicholas Murray Butler, of Columbia University, as secretary of the board. Under these auspices there will surely develop at Washington a great institution, which will in fact be a national university. It will not, however, be a rival to existing universities, but will coordinate their work; it will utilize the opportunities for study and research in the government departments, without interfering with their legitimate functions; it will be a center of research and intellectual activity, worthily representing our great universities and the scientific work of the national government.

THE CELEBRATIONS AT GLASGOW AND CHICAGO.

GLASGOW UNIVERSITY celebrated its ninth jubilee exactly at the same time that the University of Chicago celebrated its first decennial. On both occasions there were elaborate academic ceremonies, and the sciences were well represented. Indeed at Glasgow science appears to have been predominant, the four principal addresses being in celebration of four men of science, prominently connected with the university in the past. Lord Kelvin delivered an oration on James Watt, Professor Smart on Adam Smith, Professor Young on William Hunter, and Sir Joseph Hooker, in connection with the opening of the new botanical department, on his father. The LL.D. was given to somewhat over one hundred delegates, including, among Americans, J. Mark Baldwin, professor of psychology, Princeton University; William G. Farlow, professor of cryptogamic botany, Harvard University; Adolph Meyer, lecturer on psychiatry, Clark University; and R. Mark Wenley, professor of philosophy, University of Michigan. The celebration at Chicago was even more elaborate, a number of addresses being made on different subjects. The only two foreign delegates appear to have been Professor J. H. van't Hoff, the eminent physical chemist of Berlin, and Professor Marcus Dods, the theologian of Edinburgh. Eleven honorary degrees were given, including in the sciences, in addition to Professor van't Hoff, Professor E. C. Pickering, director of the Harvard College Observatory; Dr. Charles D. Walcott, director of the U. S. Geological Survey, and Professor E. B. Wilson, professor of zoology in Columbia University. The address of most interest from a scientific point of view was Dr. Walcott's on 'The Relation of the National Government to Higher Education and Research.' Mr. and Mrs. Rockefeller were present at the exercises, and President Harper took the occasion to say that the world knows what ten or twelve million dollars will do for a university, but that the time is coming for the world to learn what fifty million dollars can accomplish. As part of the ceremonies the corner stones of a number of new buildings were laid, the most important group of which is shown in the accompanying illustration.



THE LEON MANDEL ASSEMBLY HALL, THE STUDENT'S CLUB HOUSE, THE TOWER AND THE COMMONS OF THE UNIVERSITY OF CHICAGO.

THE CARNEGIE SCHOOLS.

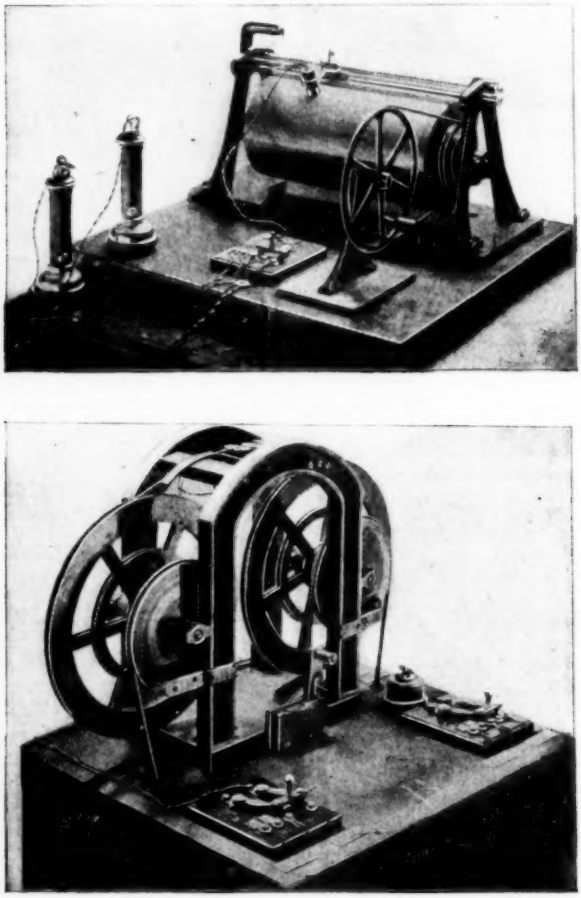
INSTITUTIONS for scientific education and research are developing in the United States with a rapidity that is truly bewildering. Industrial conditions, created by the advance of science, have produced wealth that is both widely distributed and collected in great fortunes. Several of those who have freely received have also freely given. To them the world is forever indebted, for they have not only by their contributions to education and science made new advances inevitable, but, by repaying their debt to society, they have contributed greatly to its stability. During the past month Mr. Jacob S. Rogers, of Paterson, N. J., a manufacturer of locomotives, has bequeathed nearly his entire fortune, $8,000,000 it is said, to the Metropolitan Museum of Art in New York City, and Mr. J. Pierpont Morgan has given $1,000,000 to Harvard University for its Medical School. Mr. Carnegie's gifts of $10,000,000 to the Scottish universities and of an equal sum for American libraries have recently been made, and now it appears that he is planning with equal munificence for technical schools at Pittsburg.

In the May issue of this magazine, Dr. W. J. Holland, director of the Carnegie Museum, described Mr. Carnegie's great foundation. The trustees of the Institute and Library were requested by Mr. Carnegie to draw up plans for technical schools, and they appointed an expert committee, which has just made a report. This committee consists of Professor Robert H. Thurston, director of Sibley Engineering College, Cornell University; Professor J. B. Johnson, dean of the College of Engineering, University of Wisconsin; Professor Thomas Gray, of the Rose Polytechnic Institute, and Professor V. C. Alderson, of the Armour Institute. Their report outlines a technical institute covering the whole field with unparalleled thoroughness, including a college, a high-school and special classes. The college would offer courses in the sciences, in modern languages and in all departments of engineering, and provide the fullest facilities for investigation and research, being in fact a great national school of technology. The high-school would be local in character, but would be a model for the similar schools that will surely be established in other cities. Special classes will provide instruction for those who are unable to give their entire time to study. These are only the recommendations of the committee, but there is every reason to believe that Mr. Carnegie has in view the establishment at Pittsburg of the greatest technical schools in the world.

THE TELEGRAPHONE.

MR. POULSEN, of Copenhagen, has given the name telegraphone to an instrument in which he has most ingeniously combined the telephone and the phonograph. Its general construction will be understood from the illustrations, originally published in the London 'Electrician.' The details of the two instruments differ, a short wire being used in the one and a long steel ribbon in the other, but the general principle is the same. The steel wire or ribbon passes before the poles of an electro-magnet in a telephone circuit, and is thus magnetized in a manner varying with the current in the telephone circuit produced by the voice of the speaker. When the steel wire is then passed over the poles of an electro-magnet, the same undulations will be set up in the current passing through its coils, and the sounds will be reproduced in the receiver. The reproduction is as definite as in a good telephone and much superior in quality to that of any form of phonograph. The record can be used as often as desired, and is said to last indefinitely, but it can be wiped out by passing the wire over an electro-magnet. The wire can be passed over any number of re-

ceiving magnets, and messages can thus be transmitted practically simultaneously to any number of stations. It is said also that the magnets may, in this way, be used as a telephonic relay, which would be a result of the utmost practical importance.



THE TELEGRAPHONE.

THE PLANET EROS.

THE little planet Eros bids fair to hold the attention of astronomers for several years to come. Before the observations necessary for the determination of the sun's distance had been completed, came the announcement, by Dr. Oppolzer, of the planet's variability. A variable planet, with a range of variation, such as Eros has shown, is in itself something new and striking, but this is only the beginning of the problem. Several hundred stars are known to vary their light periodically, and some advance has been made in the theory of their variability. Variable stars, however, do not become invariable, neither do invariable stars, after a time, become variable. From a variable planet, having an extremely short period and large range of variation, Eros recently became invariable.

In Europe, soon after the discovery of its variability, its range was said to be two magnitudes, that is, it shone with about six times more light at maximum than at minimum. Precise photometric measurements of the light of Eros, made by Professor Wendell, on March 12 of the present year gave a range of variation of 1.1 magnitudes and on April 12, of 0.4 of a magnitude. On May 6 and 7 no variation was perceptible, and it was less, probably, than a tenth of a magnitude. Owing to poor weather and the planet's approach to the sun, later observations have been difficult. But a slight variation was apparent in June. These unique phenomena probably are the result of the changing direction of the axis of rotation referred to the line of sight. Although the direction of this axis in space is fixed, it will constantly change with reference to an observer on the earth. When the axis, if ever, points directly towards the earth, there can be no variation of light, and the maximum range will be found when the axis is perpendicular to the line of sight. Apparently this axis has recently been pointing towards the earth. We may confidently expect that within a short time Eros will again show well marked changes, although the planet's position may not permit exact observations. On March 5, M. Ch. André communicated to the 'Astron. Nach.' a discussion, in which he assumed that the variation is due to the fact that Eros is a double asteroid. M. André even gave approximate elements for a system which appeared to him to satisfy the conditions. Professor Pickering has recently pointed out that the variations in light can hardly be accounted for by two similar bodies alternately eclipsing each other, and has suggested that the known facts can be explained by the rotation either upon an elongated, cigar-shaped body, or of a body, one side of which is much darker than the other. The solution of the interesting problems, which Eros presents, may not be possible until the next opposition, which does not occur for about two years. Eros will be in conjunction with the sun in the spring of 1902, and in opposition in the summer of 1903. The distance of the planet at that time will be great, since Eros will not be at perihelion, but this will not prevent precise determinations of the changes in light, with a telescope of sufficient power. At the next opposition, however, the path of Eros will be in the southern sky. The most favorable time for observation will be from March to August, 1903. During these months its declination will be between 30° and 45° south of the equator, which will make it difficult or impossible of observation at northern observatories.

JOSEPH LE CONTE.

In the death of Professor Joseph Le Conte, America has lost the man of science who was most honored and beloved. An age of extreme specialization and keen competition can still appreciate the general culture and broad survey of nature which make a great teacher and a great man. Other contemporary men of science have more exact knowledge of a limited field and have made more definite contributions to science, but there is perhaps no one who has done such good work in such diverse directions or whose influence has been so wide and beneficent. Le Conte was descended from a Huguenot family, driven to America after the revocation of the edict of Nantes. His father, uncle and brother were all emiment in science. Born in the South in 1828, he began to practise medicine, but his love of natural science led him to go to Harvard to work under Agassiz. He held chairs in southern universities, but these being disabled by the civil war, he accepted a call to the University of California before its opening, and for thirty-two years has been professor of geology and natural history and the leading scientific man on the Pacific coast. His teaching and

his publications have covered a wide field. His book on 'Sight' is the best English treatise on this subject; he published standard works on geology and recently a work on zoology. His special papers on these subjects and on education and philosophy are numerous and valuable. He was a member of the National Academy of Sciences, president of the American Association for the Advancement of Science and president of the Geological Society of America. He died in the Yosemite Valley on July 6; it seems fitting that death should have come suddenly in the midst of the mountains that he studied and loved. A biographical sketch of Joseph Le Conte, with a portrait, was published in THE POPULAR SCIENCE MONTHLY for January, 1878.

SCIENTIFIC NEWS.

DR. JOHN FISKE, eminent for his contributions to the theory of evolution and to American history and widely known for his popular writings and lectures, died on July 4. We regret also to record the death of Professor Peter Guthrie Tait, who, for forty years, held the chair of natural philosophy at Edinburgh and made important contributions to physical science.

A COMMITTEE, consisting of Professors Ira Remsen, J. S. Ames and W. H. Welch, has been appointed at the Johns Hopkins University to arrange a memorial to the late Professor Henry A. Rowland.

M. LAVERAN, who discovered the malaria parasite, has been elected a member of the Paris Academy of Sciences in the section of medicine, and M. Zeiller a member in the section of botany.—The following fifteen candidates have been elected members of the Royal Society: Professor Alfred William Alcock, Mr. Frank Watson Dyson, Mr. Arthur John Evans, Professor John Walter Gregory, Captain Henry Bradwardine Jackson, Mr. Hector Munro Macdonald, Mr. James Mansergh, Professor Charles James Martin, Major Roland Ross, Professor William Schlich, Professor Arthur Smithells, Mr. Michael Rodgers, Mr. Oldfield Thomas, Mr. William Watson, Mr. William Cecil Dampier Whetham, and Mr. Arthur Smith Woodward.

PROFESSOR JAMES DEWAR, the eminent chemist, has been elected president of the British Association to follow Professor A. W. Rücker, and will preside at the Belfast meeting in 1902. Professor A. S. Packard, who has held since 1878 the chair of zoology and geology at Brown University, has been elected a foreign member of the Linnean Society of London.

PROFESSOR WILLIAM JAMES, of Harvard University, gave his course of Gifford Lectures on the psychology of religion at Edinburgh during May.—Professor J. H. van't Hoff, of the University of Berlin, gave in June limited number of lectures on physical chemistry at the University of Chicago.—Dr. William Z. Ripley, of the Massachusetts Institute of Technology, has been invited to deliver the second Huxley Memorial Lecture before the Anthropological Institute of Great Britain. The first lecture was given last year by Lord Avebury, and was published in this Journal.